A Classification of Forest Habitat Types of the White River National Forest, Colorado

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INTRODUCTION

This is the second habitat type study of forest vegetation in western Colorado. An earlier study characterized the forest habitat types of the Routt National Forest (Hoffman and Alexander 1980).

Objectives

The objectives of this study were:

1. Determine and describe the forest habitat types of the White River National Forest on the basis of both reconnaissance and intensively sampled plots well distributed over the whole area of the Forest.

2. To the extent possible, relate the habitat types to soils and climatic data.

3. Relate the forest vegetation of the White River National Forest to other Rocky Mountain forests similarly studied.

The Classification of Habitat Types

It is apparent that a classification system of some kind is both useful and necessary in the management of natural vegetation as a renewable resource. There are various systems, or approaches, that are less than natural systems, used to classify natural vegetation. It is logical that a system which most nearly approximates a natural system should be of greatest value over the longest period of time. A natural system of

classification should permit a predictable relationship between immature and mature stages in the development of vegetation. This differs greatly from the cover type classification system or the continuum approach which is not a classification system; both of these view vegetation as an essentially static entity and if vegetation is altered, by fire, disease, logging, etc., on a site that was previously classified by cover type or that fit into a segment of a continuum, that site may no longer fit the classification scheme and certainly will be out of place in the continuum. The fundamentals of understanding habitat types and their potential role in vegetation science were put forth in a classic paper by Daubenmire in 1952. The importance of understanding vegetation dynamics, the outcomes of successional trends, the significance of unions as structural units of vegetation, the significance of indicator species, and the autecologic requirements of certain key species were emphasized in that paper. A detailed analysis of the habitat types of the Northern Rocky Mountains was published by Daubenmire and Daubenmire in 1968 and their views on habitat types as part of a synecologic perspective were further elaborated.

Habitat types are land areas which support or will come to support particular mature and stable plant communities in the absence of disturbance; the stable plant communities are plant associations. If intrinsic habitat factors remain intact, disturbance of vegetation by grazing, logging, fire, etc. will not alter the capacity of a habitat to regenerate the stable

community (Daubenmire 1968a). This further assumes that the flora has not been depleted from which the plant association gains its botanical composition. The plant associations, or climax communities, which develop are categorized according to Tansley (1935). The climatic climax vegetation is that which develops on deep, well-drained soils of normal topography. Edaphic and topographic climaxes are those which develop on sites where soil conditions such as nutrients, texture, moisture, etc., or where aspect and slope compensate respectively for habitat conditions which support a climatic climax. Topo-edaphic climaxes are possible where a combination of both topography and soil conditions alter habitat conditions sufficiently to permit development of a special kind of vegetation. These are all primary climax types. If a disturbance is periodic and results in a characteristic plant community that is apparently stable and reflects the kind and degree of disturbance the term disclimax is used to characterize the particular plant community. Two disclimax types that may occur are fire climax and zootic climax. The fire climax has developed a dynamic equilibrium with periodic fire which results in a distinct plant community. In the absence of fire, and if intrinsic habitat factors have not been altered drastically, successional changes may gradually cause the community to reflect the habitat type of the site. Theoretically, this is possible and in practice, examples can be located where disclimaxes show signs of reverting back to a primary climax plant community. The fact that much of the

landscape has been disturbed and most vegetation is in a seral stage of development requires an understanding of vegetation dynamics and the roles of certain key species in the composition of vegetation.

In classifying habitat types we recognize the significance of unions in vegetation structure. Unions may consist of one species or a group of species having somewhat similar life forms, phenologies, and distributions. Some unions are restricted in their distribution; others are very widespread. Trees are usually widely distributed in comparison to undergrowth unions which are controlled more by edaphic and microclimatic factors. Pinus ponderosa, as a single species union, has a very large geographic distribution. Undergrowth unions under P. ponderosa vary considerably over the geographic range and even within a limited geographic area (Hoffman and Alexander 1976). In western Colorado, Populus tremuloides occurs widely both as a seral and as a climax species. Where it is climax there are several undergrowth unions that occur beneath this dominant tree. The most luxuriant and widely distributed undergrowth union is the Thalictrum fendleri union, a rich assortment of herbaceous species, most of them forbs. On some sites the single species Heracleum sphondylium union, or the Pteridium aquilinum union forms a conspicuous layer between the overstory Populus tremuloides and the undergrowth Thalictrum fendleri union. The nomenclature for plant associations is in all cases a binomial consisting of the name of the dominant tree, e.g. Populus tremuloides, and the name of one of the ubiquitous

undergrowth species, e.g. Thalictrum fendleri. Where Heracleum produces high coverage values, and dominates the undergrowth, the second name of the binomial will be Heracleum sphondylium. Thus Populus tremuloides - Thalictrum fendleri and Populus tremuloides - Heracleum sphondyllium are two distinct habitat types though the Thalictrum union is well-represented also in the latter habitat type. In earlier reports (Hoffman and Alexander 1976, 1980) we grouped habitat types dominated by the same tree species into series, e.g. Pinus ponderosa Series, Populus tremuloides Series, etc. Within a particular series the habitat types can be recognized on the basis of undergrowth unions.

The classification of habitat types is theoretically the classification of a landscape into units of closely similar biotic potential. It has already been shown that habitat types can have predictive value for rates of tree growth (Daubenmire 1961, Roe 1967), and for susceptibility of Pinus ponderosa to mistletoe infection (Daubenmire 1961). The potential for relating habitat types to game management, reproductive habits of tree species, hydrologic cycles etc. has been reviewed by Daubenmire (1976).

LITERATURE REVIEW

A detailed studywas done to delimit habitat types of the Routt National Forest, just north of the White River National Forest (Hoffman and Alexander 1980). Forest habitat types of the Routt N.F. are the following:

Pinus flexilis - Juniperus communis h.t.

Pseudotsuga menziesii - Pachistema myrsinites h.t.

Quercus gambelii - Symphoricarpos oreophilus h.t.

Populus tremuloides - Symphoricarpos oreophilus h.t.

Populus tremuloides - Thalictrum fendleri h.t.

Populus tremuloides - Heracleum sphondyllium h.t.

Populus tremuloides - Veratrum tenuipetalum h.t.

Populus tremuloides - Pteridium aquilinum h.t.

Pinus contorta - Shepherdia canadensis h.t.

Abies lasiocarpa - Vaccinium scoparium h.t.

Abies lasiocarpa - Carex geyeri h.t.

In the Medicine Bow National Forest north of the Routt N.F. Wirsing and Alexander (1975) described the following five habitat types:

Pinus ponderosa - Carex geyeri h.t.

Populus tremuloides - Carex geyeri h.t.

Abies lasiocarpa - Carex geyeri h.t.

Abies lasiocarpa - Vaccinium scoparium h.t.

Pinus flexilis - Hesperochloa kingii h.t.

In a more limited study of *Pinus contorta* on the Front Range, Moir (1969) described a *Pinus contorta* - *Vaccinium myrtillus* h.t. and a *Pinus contorta* - *Geranium fremontii* h.t.

South of the White River N.F., Langenheim (1962) described plant communities of the Crested Butte area. She did not delimit habitat types but her data indicate she observed at least variations of some of the habitat types we studied in both the Routt N.F. and White River N.F. She very likely studied stands of at least the *Populus tremuloides* - *Thalictrum fendleri* and *Abies lasiocarpa* - *Vaccinium scoparium* habitat types.

Though never published, the preliminary study by Steen and Dix (cited by Alexander 1974) included the following habitat types for the Medicine Bow Mountains, Wyoming, the Front Range, and the San Juan Mountains, Colorado:

Picea engelmannii - *Vaccinium scoparium*
Picea engelmannii - *Polemonium delicatulum*
Picea engelmannii - *Cardamine cordifolia*
Pinus contorta - *Pachistima myrsinites*
Abies lasiocarpa - *Carex geyeri*
Abies lasiocarpa - moss species
Populus tremuloides - *Symphoricarpos* spp.
Populus tremuloides - *Thalictrum fendleri*
Populus tremuloides - *Festuca thurberi*

While these studies have been done on habitat types in Colorado, some conspicuous gaps exist in our knowledge of the habitat types of this important region. Additional studies should be done to complete our knowledge of the major habitat types of the Central Rocky Mountains.

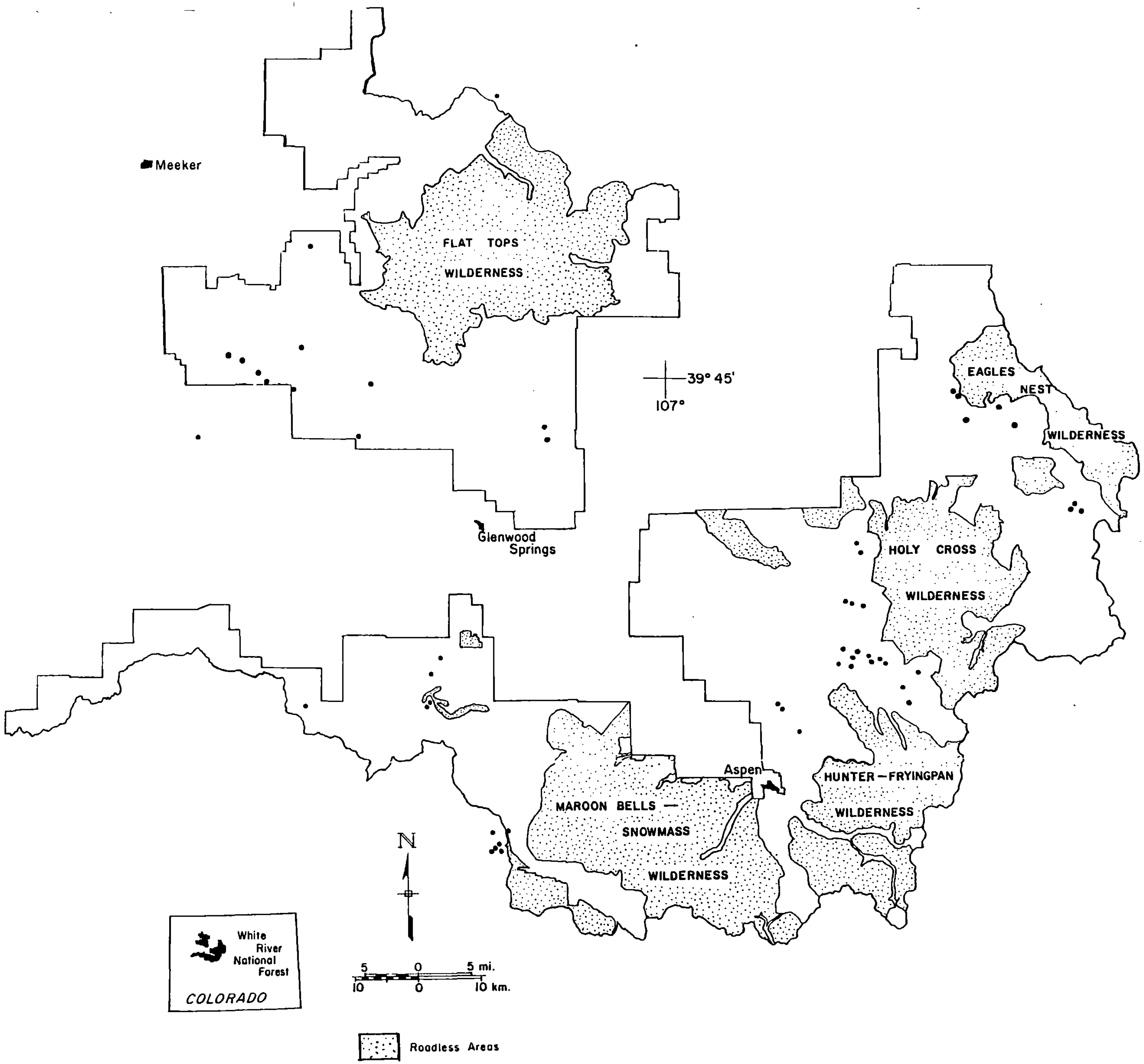
STUDY REGION

Physiography

Previous to the existence of the national forests, Forest Reserves were established to help protect areas from "wasteful timber cutting and excessive grazing" (Anon. 1941). The "first" White River National Forest was entirely on the White River Plateau, all of it located north and west of the Colorado River.

The present-day White River National Forest includes parts or all of the former White River National Forest, Leadville National Forest and Holy Cross National Forest. It is located in all or parts of Rio Blanco, Eagle, Garfield, Pitkin, Lake, and Summit Counties. The study region is part of the Southern Rocky Mountain Province of Fenneman (1931)(Fig. 1).

The White River Plateau dominates the physiography of the northwestern part of the Forest and the massive Sawatch Range dominates the entire eastern half of the forest. The smaller Elk Range and Gore Range are located west of Aspen and northeast of Vail respectively. The White River plateau exhibits a large area of late Tertiary andesite and basalt which forms the Flattops. These rocks are exposed elsewhere as well — south of Glenwood Springs to about the vicinity of Basalt (the town) bounded on the west by the Roaring Fork River and on the east by Red Table Mountain. Another smaller area is present between Eagle and Edwards. From the Flattops to the Colorado River south and east, the Plateau is severely dissected by streams and rivers forming canyons some of which are 2000 ft below the top of the Plateau. In this region of the Plateau are sedimentary deposits of limestone, sandstone, and siltstone of lower and upper Paleozoic age.


Meeker
FLAT TOPS
WILDERNESS
39° 45'
107°
Glenwood
Springs
EAGLES
NEST
WILDERNESS
HOLY CROSS
WILDERNESS
Aspen
HUNTER — FRYINGPAN
WILDERNESS
MAROON BELLS —
SNOWMASS
WILDERNESS
N
White
River
National
Forest
COLORADO
5 0 5 mi.
10 0 10 km.
Roadless Areas

The Eagle Valley depression, at the north end of the Sawatch Range, includes Red Table Mountain and exhibits sedimentary formations of Middle to late Paleozoic age. The Maroon Formation, so conspicuous between Gypsum and Eagle consists predominately of red shales, silt stones, sandstone and conglomerates. This group of substrates extends from the Eagle River south to Woody Creek - Lime Creek vicinity. East of Wolcott the Eagle River cuts through these formations then becomes their western boundary southward to the vicinities of Minturn and Red Cliff. The northern core of the Sawatch Range, east of Lime Creek — Woody Creek and west of the Eagle River in the southeastern part of the Forest, is predominately sedimentary, igneous and metamorphic rocks of PreCambrian age. Included here are granites, gneiss, and schist. Terrace deposits of Pleistocene and Recent Age are quite common east of the divide from about the latitude of Independence Pass northward to near Minturn. The Sawatch Range contains the highest peaks in Colorado, including Mt. Elbert at 14,431 ft (4,399 m). Ten peaks of the range exceed 14,000 ft (4,267 m) and numerous more exceed 13,000 ft (3,962 m).

The southern end of the Park Range, known as the Gore Range, is included within a small segment of the northeastern part of the Forest. Like the Sawatch Range, the Gore Range exhibits sedimentary, igneous, and metamorphic rocks of PreCambrian age at higher elevations. The southwest exposures of this range contact the middle to late Paleozoic sediments described above.

Climate

A limited number of weather stations are located in the region, and some characterization of climates within vegetation zones is possible (Table 1). Meeker, Rifle, Silt, and Glenwood Springs are located below the _Populus tremuloides_ zones and Shoshone is in Glenwood Canyon. Marvin, Aspen, and Nast are within the _Populus tremuloides_ zone though they are located along drainage ways which may influence both temperature and precipitation. Meredith is close to both _Populus tremuloides_ and _Quercus gambelii_ vegetation. Eagle receives 28.6 cm precipitation annually which compares with Rifle, Silt, and Meredith which receive annually 27.9 cm, 31.6 cm, and 29.3 cm precipitation respectively. The remaining stations in Table 1 are within the _Abies lasiocarpa_ zone, and annual precipitation for these stations ranges from 46.9 cm to 68.4 cm. Precipitation distribution varies considerably among the weather stations and generalizations are difficult to derive. At the lower, drier sites over 50% of the precipitation annually is received during the 6 warm months. In the _Populus tremuloides_ zone where Meredith is an exception, slightly more than 50% of the precipitation is received during the 6 cool months. The same generalization holds for stations in the _Abies lasocarpa_ zone with the exception of Leadville which receives 29% of its precipitation during the 6 cool months. Temperatures also relate generally to vegetation zones. Where temperature data have been recorded they show

Table 1. Mean temperature (T) in ^{o}C and precipitation (P) in mm from selected weather stations in and near the area of the White River National Forest. [a]

Station	Elevation		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Meeker	1903 m	T	-6.2	-3.9	+0.8	+6.3	+10.9	+15.4	+18.7	+17.8	+13.4	+7.4	+0.7	-5.1
		P	29.2	25.4	38.1	39.6	36.8	26.9	38.3	46.2	36.3	37.8	27.9	28.4
Rifle	1618 m	T	-4.9	-1.6	+3.5	+9.1	+13.7	+18.1	+21.7	+20.5	+15.9	+9.9	+2.2	-2.9
		P	23.4	20.3	23.1	25.6	20.1	17.5	25.9	30.5	23.4	27.7	19.8	21.3
Silt	1658 m	T				Temperature Data Unavailable								
		P	22.3	20.8	33.3	29.0	36.8	17.8	29.7	30.7	34.3	26.2	18.3	16.5
Glenwood Springs	1775 m	T	-4.0	-1.3	+3.3	+8.7	+13.5	+17.9	+21.7	+20.6	+16.4	+10.6	+2.4	-2.6
		P	45.7	44.4	38.9	48.3	34.5	30.2	34.5	42.4	35.8	35.6	30.7	36.8
Shoshone	1862 m	T				Temperature Data Unavailable								
		P	45.7	46.0	42.4	55.6	34.8	31.0	28.2	42.2	33.5	39.1	34.8	43.9
Marvine	2377 m	T				Temperature Data Unavailable								
		P	45.5	38.1	53.3	47.2	36.1	35.3	41.1	50.0	40.6	33.8	39.4	50.0
Aspen	2411 m	T	-6.7	-5.3	-1.8	+3.9	+8.7	+13.2	+16.5	+15.6	+12.2	+6.7	-0.9	-5.1
		P	46.0	44.4	46.5	44.2	40.4	26.9	37.6	40.6	35.6	36.3	34.3	37.6
Meredith	2385 m	T	-9.7	-5.1	-6.1	+1.3	+6.6	+11.5	+16.6	+13.4	+10.1	+1.8	-2.2	-6.9
		P	22.9	42.2	28.2	19.3	20.8	15.5	35.3	38.3	48.3	8.4	10.9	2.5
Nast	2682 m	T	-9.0	-7.6	-3.9	+0.8	+11.2	+13.2	+12.9	+9.2	+4.0	+2.6	-2.6	-8.2
		P	42.4	39.4	41.7	34.5	29.0	30.2	63.0	49.3	35.8	32.0	33.5	41.7

Table 1, cont'd.

Station	Elevation		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Eagle	2011 m	T	-7.2	-4.8	+0.3	+5.4	+10.1	+14.4	+18.0	+17.2	+13.1	+6.9	-0.5	-3.7
		P	27.2	17.0	23.4	27.7	26.7	21.1	25.9	31.2	24.6	22.6	16.8	21.3
Gilman	2652 m	T					Temperature Data Unavailable							
		P	53.6	47.7	59.7	56.4	42.9	33.3	35.3	47.7	34.3	37.6	20.6	41.1
Redcliff	2624 m	T					Temperature Date Unavailable							
		P	49.5	53.6	56.9	42.9	35.6	33.0	61.5	50.8	37.6	33.5	37.3	46.7
Leadville	3062 m	T	-7.8	-7.1	-4.9	+0.1	+5.6	+10.8	+13.8	+13.1	+9.8	+4.1	-3.1	-6.5
		P	33.5	38.3	43.4	46.5	36.6	28.7	69.3	53.6	34.3	28.2	27.2	29.7
Independence Pass	3216 m	T					Temperature Date Unavailable							
		P	72.4	59.7	80.5	84.8	47.7	30.5	63.0	49.3	33.3	35.3	55.9	71.9

[a]Data from U.S. Dept. Commerce (1959).

higher monthly means below the _Populus tremuloides_ zone which in turn is somewhat warmer than the _Abies lasiocarpa_ zone. Except for Nast, all stations collecting temperature data show highest mean monthly temperatures occur in July. At Nast the highest mean temperature occurs in June. Stations below the _Populus tremuloides_ zone show mean temperatures for July are between $+18.7^{o}$ and $21.7^{o}C$. In the _Populus tremuloides_ zone the high monthly mean temperatures are between $+12.9^{o}$ and $16.6^{o}C$. In the _Abies lasiocarpa_ zone only one station at Leadville records temperature; there the July mean is $+13.8^{o}C$.

In regions where massive mountain ranges, deep valleys and canyons and high plateaus occur, climate varies considerably from one location to another. Elevation, exposure, and wind all influence temperature and effectiveness of precipitation. If weather stations are widely scattered the data obtained can provide only general indications of climate. The data available for this report provide only a general view of climatic conditions of the White River National Forest. Plants occurring in nature integrate the climatic conditions in which they live. Groups of plants (unions) having adjusted to competition among themselves and the microclimate of their habitat may be the best indicator of their microclimate. As such, vegetation unions could be utilized to supplement climatic data obtained from instruments strategically placed to characterize microclimates of a given region.

METHODS

I began this study in 1979 when I traveled throughout the White River National Forest collecting plants and taking notes on about 150 individual sites. At each site I made a list of plants present, estimated their abundance, made a determination on the successional status of the stand, noted the dominant tree species and its successional role, and noted the elevation, aspect and slope of each site. Where possible, I also noted the geologic substrate and soil texture at each site. I tried to locate old stands of timber that showed little sign of disturbance. These are not abundant in the White River National Forest where mining, logging, grazing, and fire have impacted on the forest for many years. It is important during the first field season that stands are examined over a broad geographic extent of the region. Only in this manner can the extent and variation of the habitat types be determined. After this field season I compiled a tentative list of habitat types of the White River National Forest. This list would be reinforced or altered on the basis of two subsequent field seasons during which intensive sampling was done. In 1980 and 1981 I sampled intensively a number of the reconnaissance stands. Most were older stands in late stages of succession. Some were climax stands. I determined subjectively the most homogeneous part of the stand to be sampled. In this area of the stand I laid out a 15 x 25 m plot using stakes to mark the corners and a string to delimit the perimeter. I placed consistently the plots around the largest trees as long

as they were not obviously near game trails, ecotones, or other disturbances. Each plot also was placed parallel to the contour of the slope. The method of selecting locations for intensive sampling assured data representative of the oldest part of the stand and perhaps an overestimate of tree basal area. However, because the method was consistent, the data are comparable from stand to stand. Each plot was subdivided into three 5 x 25 m macroplots by stretching 2 - 25 m tapes across the length of the plot. Within the 15 x 25 m plot I recorded into decimeter diameter classes every tree taller than 1 m. Trees $<$1 m tall were counted within two 1 x 25 m transects placed along the inner sides of the central macroplot. Tree population data are given in Table A, Appendix. Basal areas were calculated using the midpoints of the dm diameter classes. Canopy coverage of each undergrowth species was estimated within fifty 2 x 5 dm microplots placed systematically along the inner sides of the central macroplot (Daubenmire and Daubenmire 1968). I used the method of Daubenmire (1959) to record canopy coverages of undergrowth species:

Coverage Class	Coverage Interval	Coverage Midpoint
1	1 - 5%	2.5%
2	6 - 25%	15.5%
3	26 - 50%	38 %
4	51 - 75%	63 %
5	76 - 95%	85.5%
6	96 -100%	98 %

In the field only the coverage class number was recorded for each species in each microplot. Coverage calculation was done using the coverage midpoint value for each coverage class equivalent. Frequency, the percentage of microplots in which a species occurs per stand, was also calculated. Coverage and frequency data for all species in all stands are given in Tables B - F of the Appendix.

From each stand I collected 25 soil samples of the upper dm of mineral soil. These were composited and air-dried in the field then taken to the laboratory for analysis. After screening through a 2 mm sieve the soils were tested for the following: total nitrogen, organic matter, phosphorous, potassium, calcium, magnesium, pH, salt content, and textural analysis. The results of the soils tests are given in Table G, Appendix.

Some of the plant taxonomic problems I encountered in the Routt National Forest also appeared in the present study. In the present study Osmorhiza depauperata is quite distinct in Abies lasiocarpa-dominated habitat types and in Pseudotsuga menziesii-dominated habitat types, and Osmorhiza occidentalis is distinct in Populus stands. However, there are apparent hybrids occurring through much of the Populus tremuloides zone and these have been listed as Osmorhiza sp. I found no specimen that was clearly Osmorhiza chilensis. In this region Arnica cordifolia and A. latifolia apparently hybridize. Specimens of both species were encountered in this study but I did not observe obvious hybrids. The roses encountered are all listed as Rosa sp. This plant was seldom observed in flower and apparently hybrids of Rosa woodsii X R. acicularis are not uncommon. I have also listed Fragaria sp. to cover apparent hybrids between F. virginiana and F. ovalis. I never observed Fragaria in flower or in fruit at the study sites.

Finally, I encountered few if any hybrids of Vaccinium. *Vaccinium scoparium*, *V. myrtillus*, and *V. cespitosum* all occurred in *Abies lasiocarpa*-dominated vegetation.

Over an elevational range of 1,143 m, from 2,210 m to 3,353 m, I collected 21 samples of cones under isolated spruces. The occurrence of *Picea pungens* in this region, particularly along streams, suggested the possibility that it, or hybrids with *Picea engelmannii* (Daubenmire 1972), might occur over a range of elevations, and perhaps as part of habitat types studied. The sample size was at least 10 cones per location. I collected cones in only 21 locations as it was not the primary intention here to study hybridization of spruces. This small sample might, however, provide an indication of the occurrence of hybridization of spruces in the White River National Forest and, to some extent, the elevational range of the hybrids. The methods to assess possible hybridization were modified from Daubenmire (1972). For each collection of cones I measured cone lengths and diameters at the broadest point. I also removed a scale from the middle of the cone and measured its length, width and percentage free cone scale (Daubenmire 1972). To calculate hybrid index values I multiplied cone length x cone width/10, cone scale length x cone scale width/10, and the percentage free cone scale. The ranges of values for these three measurements were subdivided into five equal segments. The equivalent hybrid index values were 0, 1, 2, 3, 4 for the five segments. The three values were summed for each cone. A cone most representative of *Picea pungens* could have a summed index value of 12, while a cone most characteristic of *Picea engelmannii* could have a summed index value of 0. Characteristics tested for hybridization are based entirely on cones of these spruces, and this may limit the interpretation placed on the results.

RESULTS AND DISCUSSION

Within the study region forest vegetation ranges from xerophytic Pinus edulis - Juniperus scopulorum-dominated vegetation at low elevations where the climate is warm and dry to mesophytic Abies lasiocarpa - Picea engelmannii-dominated vegetation at high elevations where the climate is cool and moist. Owing to time limitations, the Pinus edulis-Juniperus scopulorum- and Quercus gambelii-dominated vegetation was not sampled intensively. However, reconnaissance was done over the area occupied by these vegetation types. Most of these lower elevation forests are also outside the Forest boundaries and grazing has had considerable impact on their composition. Most of my field time was therefore spent evaluating habitat types from the lower edge of the Populus tremuloides zone through the Abies lasiocarpa zone at high elevations. These zones occupy most of the land area in the White River National Forest.

Populus tremuloides Series

Populus tremuloides is widely distributed in western Colorado. In the Routt National Forest it is the most common forest tree species occurring as both a seral and a climax species (Hoffman and Alexander 1980). Jones and Markstrom (1973) calculated that Populus tremuloides covers about 1.6 million acres in western Colorado.

In the White River National Forest Populus tremuloides also occurs over a large area, from low elevation stands at about 2,438m (8,000 ft) where the climate is warm and relatively dry to high elevation stands at about 3,200m (10,500 ft) where the

climate is cool and moist. At the elevational extremes Populus is often stunted, especially in high elevation stands where it frequently occurs on very rocky substrates with sparse undergrowth. At the lower edge of its range it is also small-statured and sometimes coexists in thickets with Quercus gambelii, Amelanchier alnifolia, and Prunus virginiana. Throughout most of its distribution, however, it forms large stands of sizable trees, particularly from about 2,530m (8,300 ft) to 3,048 (10,000 ft). The stands occur on all exposures though most stands I sampled faced between 90^{o} and 180^{o}.

There has long been discussion regarding the seral and/or climax role of Populus tremuloides in the central and southern Rocky Mountains. Most investigators have considered the species here to be seral to Picea engelmannii, Abies lasiocarpa and Psudotsuga menziesii. Many, perhaps most, stands of Populus tremuloides have been initiated and perpetuated by fire. In some areas the resulting stands appear to be perpetuating themselves without encroachment by conifers. Consideration of aspen stand dynamics must include soil and microclimatic changes which accompany the dominance of aspen. As a deciduous species, aspen loses its leaves annually and owing to litter decomposition, nutrient cycling and the altered microclimate, the undergrowth is considerably different from that of coniferous forests of the same region. How much the changed conditions affect potential regeneration of coniferous species is unknown. It is possible these factors retard, perhaps indefinitely, the successful invasion by conifers. Other factors may play a role. The soil

type is no doubt important. Some soils may be altered more readily than others by the yearly addition of organic matter and nutrients. Soil texture may also be important. The proximity of conifer seed sources must be considered. Large burns effectively remove conifer seed sources from at least a central portion of the burned area. Under such conditions, aspen stands following the burn could exist for many years without a threat of conifer reinvasion.

In the White River National Forest, as in the Routt National Forest, there are plant communities dominated by aspen which show no indication of being seral to coniferous forests. I consider these as habitat types dominated by aspen.

Populus tremuloides - *Symphoricarpos oreophilus* h.t.---As in the Routt National Forest, the Populus-Symphoricarpos h.t. in the White River National Forest occurs generally at the lower edge of the Populus zone. Stands sampled range from 2,591 m (8,501 ft) to 2,858 m (9,377 ft). This elevational range is higher than in the Routt N.F. for the same h.t. Four of the 8 stands sampled are on level topography, three stands on NE facing slopes and one stand on a W facing slope. Edaphic characteristics of upper dm mineral soil samples are listed in Table G. The soil textures are loams and clay loams. Soil nutrient status is similar to that of several other h.ts. in the *Populus tremuloides* series. Tree basal areas among the stands sampled range from 22.5 m^2/ha to 57.7 m^2/ha (Table B). Xylem rings counted at breast height range from 92 to 177.

The *Symphoricarpos oreophilus* union characteristically has a number of shrub species. In the White River N.F. *Amelanchier alnifolia*, *Prunus virginiana*, and *Mahonia repens* are present but with lower constancies than in the Routt N.F. Constancy and mean coverage of the shrubs in the *Symphoricarpos oreophilus* union are as follows:

Species	Constancy	Mean Coverage
Symphoricarpos oreophilus	100%	23. %
Amelanchier alnifolia	38%	4.2 %
Prunus virginiana	25%	7.5 %
Rosa sp.	63%	3.5 %
Mahonia repens	13%	3.2 %

Additional shrubs include *Pachistima myrsinites*, *Sambucus racemosa*, and *Sorbus scopulina*.

Herbaceous species with 100% constancy in the stands sampled are *Carex geyeri*, *Elymus glaucus*, *Galium boreale*, *Geranium richardsonii*, *Lathyrus leucanthus*, *Taraxacum sp.*, *Thalictrum fendleri*, and *Vicia americana*. These species are characteristic of the *Thalictrum fendleri* union. Indeed, throughout the vegetation matrix dominated by *Populus tremuloides* in both the Routt and White River N.F., the *Thalictrum fendleri* union is represented in most stands. The structure of Populus-Symphoricarpos vegetation consists of the tree and shrub unions coexisting with the *Thalictrum fendleri* union.

A shrubby undergrowth with the above, or closely related species, occurs under aspen in Gunnison County (Morgan 1969), in the Crested Butte Area (Langeheim 1962), in the Uinta Basin (Graham 1937) and in the Wind River Mountains, Wyoming (Reed 1971). The Populus-Symphoricarpos vegetation appears to range widely across the western slope in Colorado as well as into adjacent areas. In central Idaho Youngblood and Mueggler (1981) described a Populus-Symphoricarpos _community type_: their terminology reflects a doubt about the climax status of this vegetation.

At its lower edge the Populus-Symphoricarpos h.t. contacts _Quercus gambelii_ or _Pinus edulis-Juniperus spp._ or _Artemisia tridentata_-dominated vegetation. Along the more mesic contacts the Populus-Symphoricarpos vegetation grades into more mesophytic vegetation dominated by _Populus tremuloides_. Most frequently it is the Populus-Thalictrum h.t.

Populus tremuloides - _Pteridium aquilinium_ h.t.--- This habitat type is not widespread in the White River N.F. and only one stand was sampled. It is located on McClure Pass at 2,682 m (8,800 ft) elevation. Edaphic characteristics listed in Table G show nothing to distinguish this h.t. from others in the _Populus tremuloides_ series, except for the Populus-Carex h.t. described below.

Populus is the only tree species in the stand sampled and it is represented by 5 size classes (Table A). The stand sampled is at least 100 yr old. One of the trees cored had 101 xylem rings at breast height. The undergrowth of this h.t. typically is dominated by _Pteridium aquilinium_ which is a single species union. Under Pteridium are members of the Thalictrum

union; most conspicuous in this stand are Elymus glaucus, Aster engelmannii, Fragaria sp., Galium boreale, Lathyrus leucanthus, Thalictrum fendleri and Vicia americana. Symphoricarpos oreophilis and Heracleum sphondyllium are also present (Table C). Shrubs are not a conspicuous part of the undergrowth in the stand sampled. In the Routt N.F. 12 shrub species occurred in the 7 stands representing this h.t. Also in the Routt N.F. this h.t. occurred in areas where soil moisture drainage might be impeded.

Pteridium aquilinium, like Populus tremuloides, establishes rapidly on burned areas. Often these species are replaced as succession advances. However, there are for Pteridium as for Populus situations in which succession advances little beyond the Pteridium stage. The long-lived occurrences of Pteridium aquilinium have been documented in Finland where Oinonen (1967) reported individual clones of Pteridium aquilinum reached 1400 years in age and up to 138,000 m^2 in area.

The development of the Populus-Pteridium h.t. in Colorado occurs on sites where Pteridium and Populus both establish quickly after a fire and remain over a considerable period of time. Though the time required has not been determined, the Thalictrum union also develops on the same sites. These communities appear to be quite stable. I found no mature stands of Populus tremuloides in which Pteridium appeared to be declining in vigor or in coverage.

Populus tremuloides - Heracleum sphondyllium h.t.--- As in the Routt N.F. this h.t. has limited distribution in the White River N.F. The two stands sampled in the White River N.F. occur

at 2,713 m (8,900 ft) to 2,957 m (9,700 ft) and on exposures of 156^{0} and 154^{0} respectively. Thus, they are somewhat higher on the slopes and face to the SE compared to their positions in the Routt N.F. where they occur generally 300 m (984 ft) lower and face N to NE. Edaphic characteristics are similar to those of the Populus-Thalictrum h.t. (described below).

Tree population structure shows a gap in that trees 1-2 dm dbh are absent from both stands though both have apparently adequate numbers of seedlings as well as larger size classes represented (Table A). Two of the four stands of this h.t. in the Routt N.F. also lacked trees of the smaller size classes. I do not know if the absence of smaller trees indicates the beginning of the decline of the tree populations. If so, there is no apparent successor to Populus at the time I sampled these stands. Stand 35 was 142 years old and stand 54 was 97 years old based on xylem layers at breast height.

The undergrowth is dominated by Heracleum sphondyllium; its coverage is 67% and 48% respectively in the two stands sampled. Under the Heracleum are members of the Thalictrum fendleri union.

The physiognomy of Heracleum-dominated undergrowth is that of a tall layer, 1-2 m, of Heracleum with horizontally-oriented leaves appearing to shade effectively any species occurring under it. Under it, however, are members of the Thalictrum fendleri union. The undergrowth coverage, exclusive of Heracleum, is not correlated with that of Heracleum, as shown below. Only in stand 37 in the Routt N.F. where Heracleum has a coverage of 80%

are the remaining species reduced significantly in coverage. Owing to the complexity of the undergrowth vegetation in this h.t. the sums of coverage are quite impressive.

	Stand	Heracleum Coverage	All other species coverage	Number of Undergrowth Species
Routt N.F.	37	80%	51.1%	19
	49	41%	132 %	25
	20	36%	101 %	21
	8	19%	113.8%	30
White River N.F.	35	67%	114.4%	19
	54	48%	159.1%	22

In the Crested Butte area, south of the White River N.F., Langenheim (1962) reported Heracleum occurred in half of the mature aspen stands and had an average coverage of 2.0%. In Gunnison County, Colorado, Morgan (1969) found Heracleum in 60% of his aspen stands and it had an average coverage of less than 5%. Youngblood and Mueggler (1981) described a *Populus tremuloides* - *Heracleum sphondyllium* (they named the species *H. lanatum* which has been changed to *H. sphondyllium*) community type occurring on mesic sites at mid-elevations. They suggest the type can be found throughout Wyoming though it does not occur in the Bighorn Mountains (Hoffman and Alexander 1976), the Wind River Mountains (Reed 1971), or the Medicine Bow Mountains (Wirsing and Alexander 1975). Sampson (1925) listed Heracleum as an undergrowth species in aspen stands in Utah.

Populus tremuloides - Thalictrum fendleri h.t.---This is the most common h.t. dominated by *Populus tremuloides* in the White River N.F. Stands sampled occur from 2,560 m (8,400 ft) to 3,048 m (10,000 ft) elevation and on topographic sites ranging from level to 40% slope. The stand exposures are mainly NE to SE with one each facing SW and NW. In the Routt N.F. the same h.t. occurs within a similar range of elevation though somewhat lower, from 2,475 m (8,120 ft) to 2,957 m (9,700 ft) with most of the stands also facing NE to SE.

Soils of this h.t. are loams, from sandy loams to clay loams. Soil nitrogen content ranges from 0.27 to 0.45% ($\bar{x}$ = .32 ± .06) and organic matter content ranges from 3.3 to 6.6% ($\bar{x}$ = 4.8 ± 1.2). Soil calcium content ranges from 1,364 to 4,141 ppm ($\bar{x}$ = 2,668 ± 897). Other edaphic characteristics are listed in Table G.

Tree basal areas range from 31.2 to 68.6 m^2/ha with a median value of 44.7 m^2/ha. Stand ages based on xylem layer counts at breast height range from 73 to 179. At least two stands, 39 and 49, may be older but central parts of xylem of larger trees in these stands have been decayed by fungi thus eliminating the possibility of aging the trees. In each of the 12 stands of this h.t. sampled, there are at least 5 size classes of trees represented. In only one stand, number 53, is there a gap in the presence of trees of any size class (Table A). In stand 40 there are 8 size classes present including one tree in the 6-7 dm dbh size class. In stands of this h.t. in the Routt N.F. there was a maximum of 7 size classes represented and size classes were

missing in the tree populations of 7 stands sampled there. None had trees in the 6-7 dm dbh class and the maximum basal area there was 65.7 m^2/ha. In the present study stands 39 and 40 have basal areas of 68.2 and 68.6 m^2/ha respectively. These two stands are located near Road 600 above Dotsero between Coffee Pot Campground and Dead Horse Gulch. Both stands appear to be very old, and have numbers of fallen trees. Within dissemination distance are old *Abies lasiocarpa* though it has not become established in these two stands.

Stand number 3 is 179 yr old and climax. Six size classes of trees are present up to and including 4-5 dm dbh (Table A). Characteristic members of the *Thalictrum fendleri* union are well represented. Stand 40 is also representative of this h.t. The following list gives coverage values of characteristic species of the Thalictrum union which occur in stands 3 and 40. On the right are their constancy values for the 12 stands sampled in this study.

SPECIES	% COVERAGE STAND 3	% COVERAGE STAND 40	% CONSTANCY
Bromus ciliatus	5.6	1.2	92
Carex geyeri	6.5	2.7	92
Elymus glaucus	5.2	0.7	100
Aster engelmannii	3.6	2.3	83
Delphinium barbeyi	---	18.	42
Geranium richardsonii	3.2	0.9	83
Hydrophyllum capitatum	5.6	---	42
Lathyrus leucanthus	2.5	0.8	100
Ligusticum porteri	60.	52.	58
Osmorhiza sp.	17.	26.	83
Thalictrum fendleri	6.6	59.	100
Valeriana occidentalis	2.5	1.2	83
Vicia americana	1.0	---	83

Other characteristic members of this union which are ordinarily less conspicuous include *Melica spectabilus*, *Aquilegia caerulea*, *Erigeron elatior* and *E. speciosus*.

The composition of this rich union at any particular site depends on numerous factors not the least of which is chance. In most stands Thalictrum has a coverage of 50% or more. In stand 3 its coverage is just 6.6%. However, note that Ligusticum porteri and Osmorhiza sp. have coverages of 60% and 17% respectively. In stand 40 Thalictrum has a coverage of 59% and Ligusticum and Osmorhiza have coverages of 52% and 26% respectively. In numerous other stands of this h.t. Ligusticum and Osmorhiza provide much less coverage. In stand 3 Hydrophyllum capetatum has a coverage of 5.6% and in stand 40 it is absent. In stand 3 Delphinium barbeyi is absent and in stand 40 it has a coverage of 18%. It is important to recognize the array of possible combinations of species composition and coverage values that a given h.t. may exhibit. As in the Routt N.F. I recognize the Thalictrum fendleri union as a rich mixture of herbaceous species primarily the composition and coverage of which can vary considerably. I have allowed more than 15-25% coverage differences for a given species from stand to stand. The coverage of Thalictrum in stands 3 and 40 is a case in point. Indeed, Thalictrum need not be present at all for one to recognize the Thalictrum union, for it is the aggregation of species as a group which has greater significance than the presence or absence of a single species. A single species is important in the structure of a union where it is shown to correlate with one or more environmental factors. In the absence of such a correlation one might still split off as h.ts. or phases of h.ts. stands in which a single species is so conspicuous and (perhaps) dominant that not to recognize these

stands as different would defy sound ecological judgment. Where Heracleum sphondyllium dominates the undergrowth its stature, coverage, and very probably productivity dictate recognition of it as a distinct union. This is done in spite of not showing a correlation with some environmental factor or factors. In both the Routt N.F. and the White River N.F. it appears that the Populus-Heracleum h.t. occurs on areas of more favorable moisture balance than those of the Populus-Thalictrum h.t., though quantitative data were not obtained on this point. Over much of the area of the Populus-Thalictrum h.t., as well as other Populus-dominated h.ts., sheep and cattle graze the vegetation. Species favored by grazing these h.ts. include Senecio serra, Stellaria jamesiana, Rudbeckia lacinatum and Fragaria sp., Achillea millefolium, Galium boreale, and Nemophila breviflora. Other less conspicuous species may be added to this list.

As in the Routt N.F. the Thalictrum fendleri union is widespread and occurs throughout the elevational range of Populus tremuloides.

Populus tremuloides - Carex geyeri h.t.---This habitat type has a restricted distribution in the White River N.F. and it was not recognized in the Routt N.F. The elevational range of the stands sampled is 2,972 m (9,790 ft) to 3,033 m (9,950 ft). All 4 stands sampled are on south-facing slopes (Table B).

Tree basal areas of the stands range from 26.4 to 47.0 m^2/ha. Ages of stands based on xylem layer counts at breast height are 103 to 130 years.

In 3 of the stands sampled Populus is present in 5 size classes, the largest is 3-4 dm dbh. In the fourth stand trees taller than 0.5 m of the 0-1 dm size class are absent. Tree population structures are given in Table A.

This h.t. differs from the Populus-Thalictrum h.t. in both undergrowth vegetation and edaphic factors. The undergrowth of this h.t. has a greater shrub element; _Amelanchier alnifolia_, _Mahonia repens_, _Pachistima myrsinites_, _Rosa sp._, and _Symphoricarpos_ oreophilus are present in at least half of the stands.

The undergrowth is dominated by _Carex geyeri_. Characteristic members of the undergrowth with their average coverage and constancy values are the following:

SPECIES	% COVERAGE	% CONSTANCY
Carex geyeri	37.5	100
Poa interior	5.6	75
Arnica cordifolia	4.1	75
Epilobium angustifolium	0.3	100
Fragaria sp.	14.0	100
Smilacina racemosa	1.1	75

Compared to the _Thalictrum fendleri_ union, the composition of the _Carex geyeri_ union is somewhat depauperate. Herbaceous species characteristic of the Thalictrum union which are absent or poorly represented in the _Carex geyeri_ union are _Aster engelmannii_, _Erigeron elatior_, _E. speciosus_, _Geranium richardsonii_, _Hydrophyllum capitatum_, _Ligusticum porteri_, _Osmorhiza sp._ and _Valeriana occidentalis_. _Carex geyeri_ is widely distributed in the _Populus tremuloides_ zone and through part of the _Abies lasiocarpa_ zone. As shown in Table B, Carex is common in the Populus - Thalictrum

h.t. producing as much as 59% coverage and 92% frequency in stand 15. Additionally, it is common in stands of the Populus-Symphoricarpos and Populus-Heracleum h.ts. Alone, it has little indicator significance because it is so common over a large area. However, the luxuriance of the Thalictrum union, with or without Carex, and the relative austerity of the Carex union are important and lend to the indicator significance of these two unions.

The soil textures of this h.t. are loams and sandy loams. The soils appear to be derived from igneous rocks. Other edaphic characteristics are significantly different from those of the Populus - Thalictrum and Populus - Symphoricarpos h.ts. as shown in Table 2.

In comparison to soils of the Populus-Thalictrum and the Populus-Symphoricarpos h.ts., soils of the Populus-Carex h.t. have significantly lower quantities of calcium, nitrogen, organic matter, and phosphorus. The amount of potassium is also lower than that of the Populus-Symphoricarpos h.t. These differences are consistent and valuable in characterizing the Populus - Carex h.t.

Table 2. Comparison of edaphic characteristics of the *Populus tremuloides - Carex geyeri*, *P. tremuloides - Symphoricarpos oreophilus*, and *P. tremuloides - Thalictrum fendleri* h.ts. Values given are means ± standard errors.

Edaphic Characteristics	Populus - Symphoricarpos h.t.	Calculated t values [a]	Populus - Carex h.t.	Calculated t values [b]	Populus - Thalictrum h.t.
Ca, ppm	2,848 ± 235	3.6[c]	1,477 ± 283	2.5[c]	2,668 ± 259
Mg, ppm	160 ± 10	2.0	117 ± 22	1.7	188 ± 22
K, ppm	654 ± 60	2.8[c]	415 ± 35	1.5	671 ± 94
N, %	0.34 ± .03	5.0[c]	0.15 ± .02	5.7[c]	0.34 ± .02
O.M., %	4.94 ± .48	3.7[c]	2.45 ± .24	3.9[c]	4.83 ± .34
pH	6.2 ± .12	0.5	6.1 ± .05	0.4	6.2 ± .06
P, lb/A	86 ± 15	2.8[c]	26 ± 7.0	2.2[c]	67 ± 10

[a]This column of calculations is based on the comparison of the Populus - Symphoricarpos and Populus - Carex h.ts.

[b]This column of calculations is based on the comparison of the Populus - Carex and Populus - Thalictrum h.ts.

[c]Significant at the 0.05 probability level.

Pseudotsuga menziesii Series

Pseudotsuga menziesii is not a widely distributed tree in the Routt N.F., the White River N.F. or in the Crested Butte area to the south. In all three locations it occurs in small stands on steep slopes with shallow soils. This contrasts with the greater abundance and distribution of Pseudotsuga on the Front Range in Colorado (Marr 1961). It has been suggested that Pseudotsuga was once very abundant in the Routt N.F. but was eliminated by fire and replaced by aspen (Bates 1925). I could find no similar reports of abundant Pseudotsuga and its destruction by fire in the White River N.F.

Pseudotsuga menziesii - *Pachistima myrsinites* h.t.--- As in the Routt N.F. the Pseudotsuga - Pachistima h.t. occurs in the White River N.F. on steep slopes that face west to northwest. I sampled two stands of this h.t. at elevations of 2,560 m (8,400 ft) and 2,697 m (8,850 ft). These stands are 83 and 120 yr old based on xylem layer counts at breast height. The basal areas are 30.4 and 31.4 m^2/ha. In one stand above Brush Creek south of Eagle one Pseudotsuga stump, remaining from a fire, measures 8-9 dm dbh. The undergrowth of these stands is dominated by *Pachistima myrsinites* and shrubs are common. Indeed herbaceous species are not abundant in these stands (Table D). This h.t. is more common in the White River N.F. than in the Routt N.F. From the data obtained it appears that steep rocky slopes, usually facing NW to N are primary sites on which this h.t. occurs. I have observed Pseudotsuga stands in the region which are seral to *Picea engelmannii* and *Abies lasiocarpa*.

Vegetation Zonation and Ecotones of the *Populus tremuloides* and *Pseudotsuga menziesii* Zones

Though the *Populus tremuloides* and *Pseudotsuga menziesii* zones generally occur at midelevations, the contacts they make at their upper and lower elevations vary somewhat. As shown in Fig. 2 the Pseudotsuga zone on steep rocky substrate is above the Populus zone. Populus zone occurs on deep fine textured soil of considerably less slope. At its lower edge the Populus zone contacts the *Quercus gambelii* zone. As shown in Fig. 3 the Pseudotsuga zone is again above the Populus zone, but in this deep canyon along the Frying Pan River the lower edge of the Populus zone contacts the *Abies lasiocarpos* - *Picea engelmannii* zone. North of the White River N.F. an interesting zonation occurs north of Wolcott along the Colorado River. Here Pseudotsuga is low on the slopes close to the river and above it high on the slopes is *Pinus edulis* dominated vegetation. As shown in Fig. 4 the Populus zone is on the lower slope where moisture is more favorable close to West Elk Creek. Higher on the slope are the *Quercus gambelii* and *Artemisia tridentata* zones. The three zones here are inversed in comparison to their positions diagrammed in Fig. 2. As shown in Fig. 5 the Pseudotsuga zone may be absent and the upper edge of the Populus zone contacts *Abies lasiocarpos*-*Picea engelmannii* dominated vegetation. Again the lower, drier, edge of the Populus zone contacts the Quercus zone. This is a

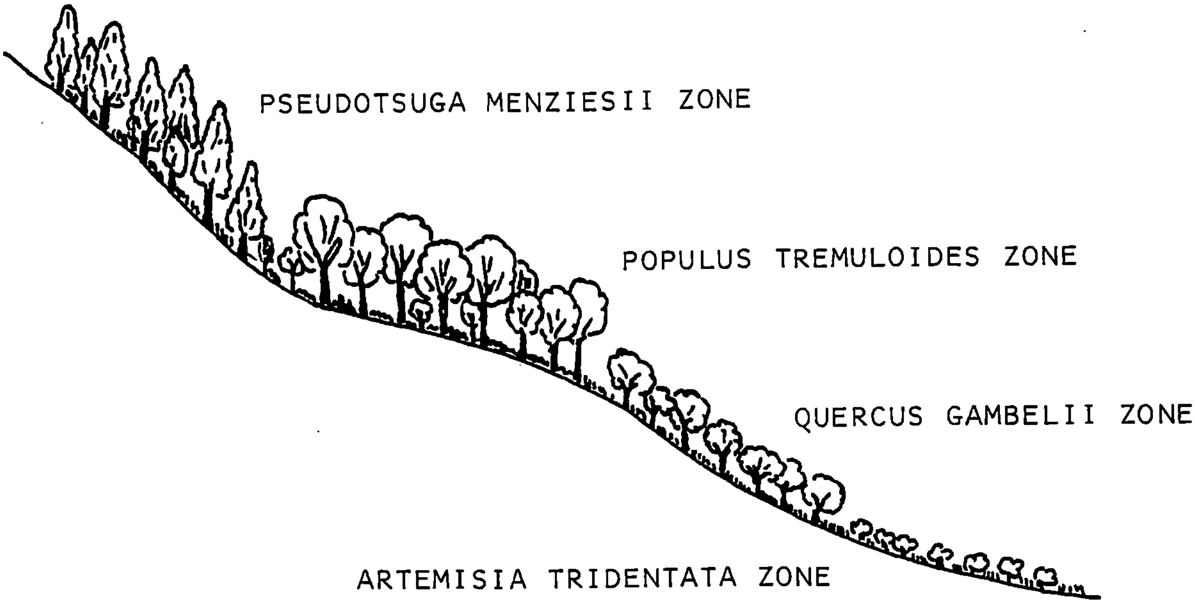


FIG. 2. VEGETATION ZONATION ALONG BRUSH CREEK SOUTH OF EAGLE.

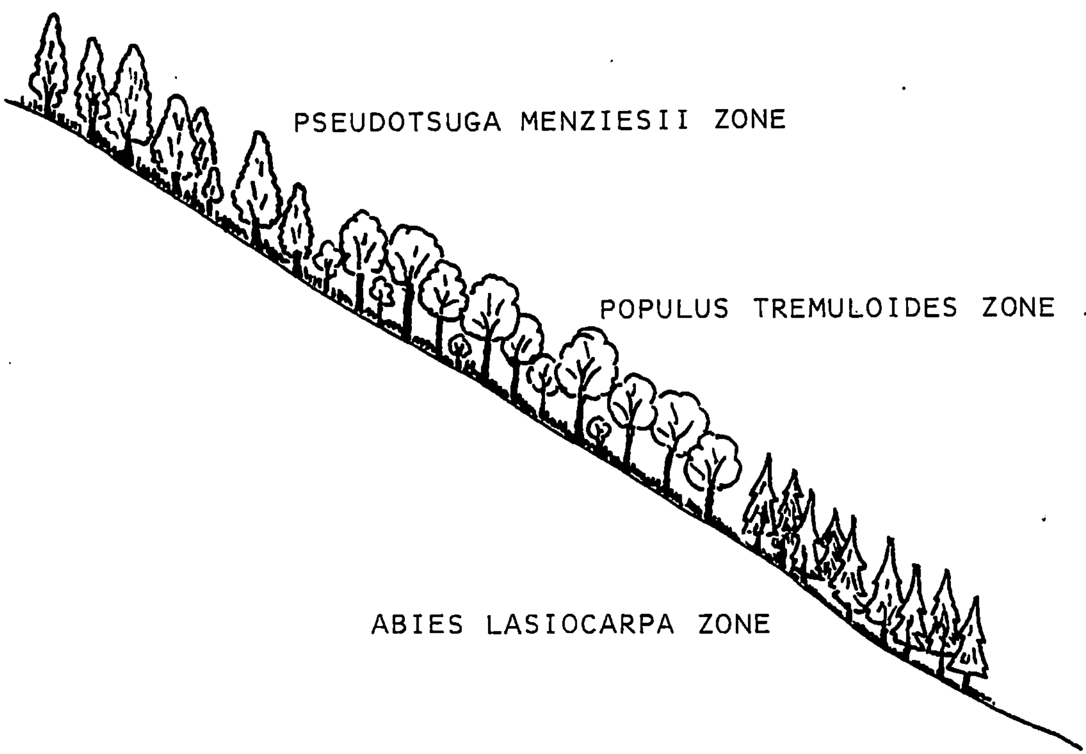


FIG. 3. VEGETATION ZONATION IN CANYON OF THE FRYING PAN RIVER EAST OF BASALT.

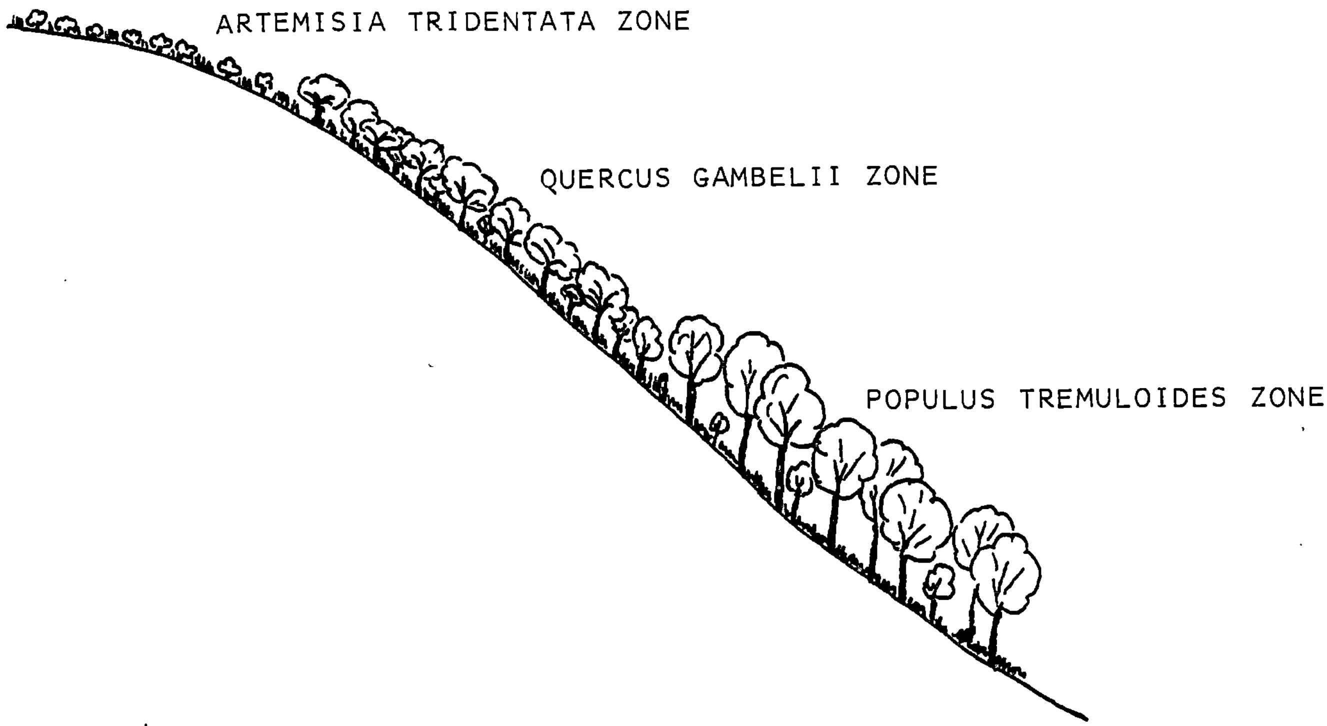


FIG. 4. VEGETATION ZONATION ABOVE WEST ELK CREEK NORTH OF NEWCASTLE.

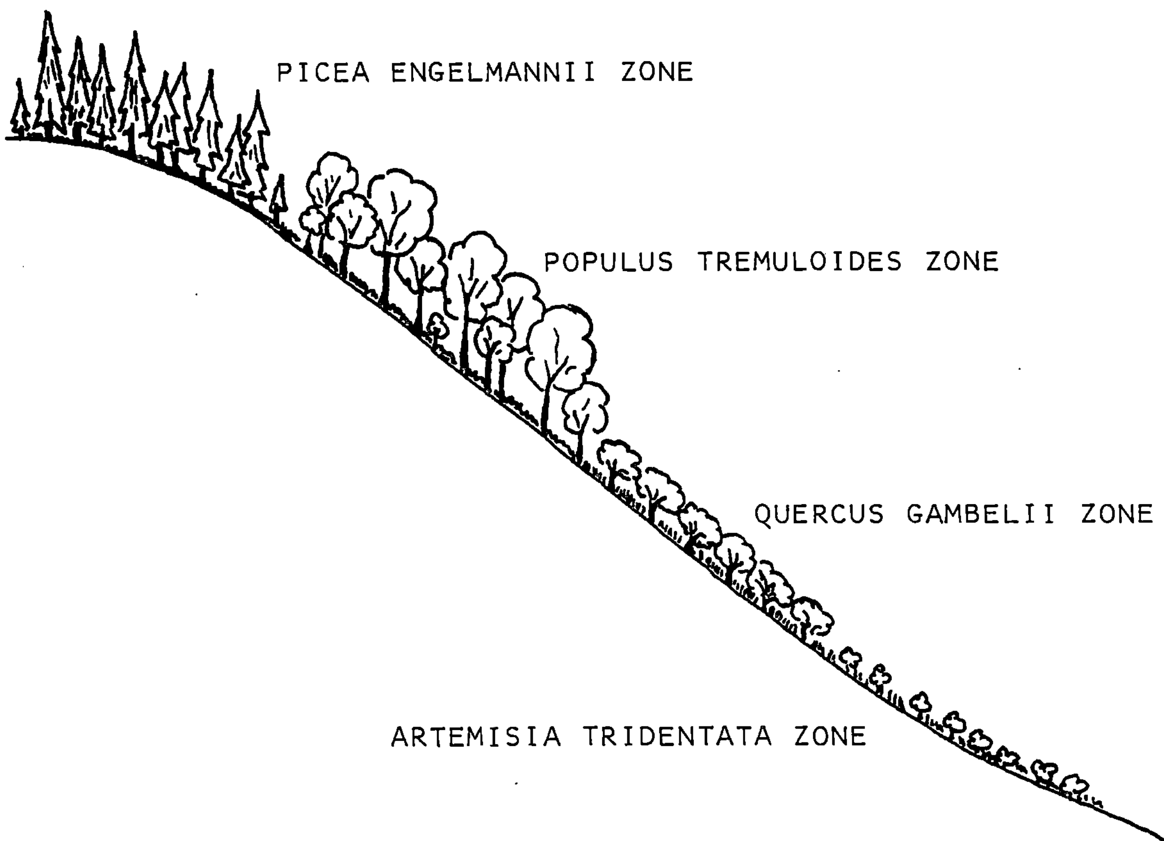


FIG. 5. VEGETATION ZONATION ABOVE WOODY CREEK NORTH OF ASPEN.

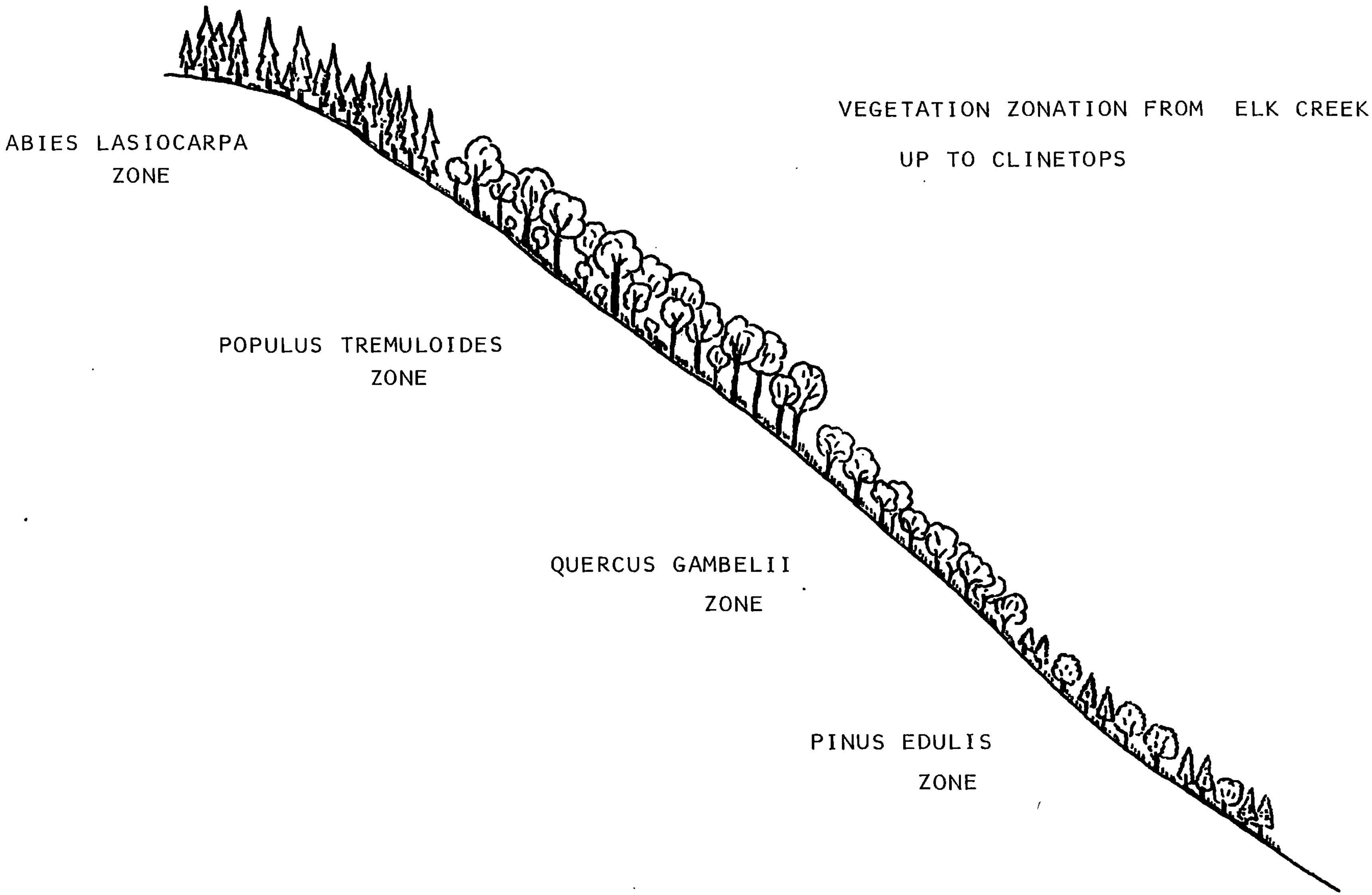


FIG. 6. VEGETATION ZONATION ABOVE ELK CREEK TO CLINETOPS NORTHEAST OF NEWCASTLE.

rather typical pattern of vegetation zonation in the White River N.F. A generalized zonation of vegetation from Elk Creek to the Clinetops is shown in Fig. 6. Here the zonation is similar to that of Fig. 5 except for the presence of the Pinus edulis zone below the Quercus zone.

Vegetation zonation can be characterized generally, but the generalizations are repeatedly defied by exceptions. Vegetation zonation reflects the complex topographic - microclimatic patterns of the region. For this reason climatic data collected at a limited number of weather stations may be of limited value as a tool in defining the distributions of natural vegetation in this study. Also, for this reason, the vegetation itself may be the most reliable indicator of microclimatic conditions along the mountain slopes and in the valleys and canyons.

Abies lasiocarpa Series

The subalpine zone is characterized by forests dominated by *Abies lasiocarpa* and *Picea engelmannii* with *Pinus contorta* and *Populus tremuloides* occurring as seral species. In some locations *Pseudotsuga menziesii* is a seral species in this zone. Subalpine forests are important in both Wyoming and Colorado where they constitute the "largest and most valuable timber resource" (Alexander 1974).

In the Routt N.F. we sampled stands ranging in elevation from 2,365 m (7,760 ft) to 3,078 m (10,100 ft). In the White River N.F. our stands range from 2,713 m (8,400 ft) to 3,414 m (11,200 ft). Stands of spruce-fir forest occur at somewhat higher and lower elevations on topographic positions that compensate for the warmer, drier climate of lower elevations and the cooler, moister climate of higher elevations. As indicated above, precipitation in the subalpine zone of the White River N.F. ranges from 46.9 cm to 68.4 cm. The only temperature data, from Leadville, indicate a July mean of 13.8^{o}C. The subalpine zone is definitely cooler and more mesic than the vegetation zones below it.

In naming h.ts. of this zone I have been consistent with others who use *Abies lasiocarpa* in naming the h.ts. In all stands sampled I found *Picea engelmannii* to be codominant with Abies, or a potential addition to the stands.

Abies lasiocarpa - Vaccinium scoparium h.t.--- This h.t. was sampled over an elevational range of 671 m (2,200 ft) from 2,743 m (9,000 ft) to 3,414 m (11,200 ft). Basal areas of the stands sampled range from 28.1 m^2/ha to 93.8 m^2/ha. The ages of the stands, based on xylem layer counts at breast height, range from 78 yr to >300 yr. The stands sampled can be subdivided into climax, near-climax, and those which are seral, as shown below:

SERAL STANDS	NEAR-CLIMAX STANDS	CLIMAX STANDS
50	9	51
55		1
12	28	22
13	47	23
20	21	45
42		
46		
52		

Basal areas among the seral stands range from 28.1 m^2/ha to 63.0 m^2/ha in stand 46. Ages are from 78 yr to 117 yr. The large basal area of stand 46 results from the current dominance of Pinus contorta which is present in 6 size classes up to and including 4-5 dm dbh. The four stands that are near-climax have basal areas of 40.2 m^2/ha to 68.8 m^2/ha in stand 9. Stand 9 has a typical climax population structure of Abies lasiocarpa with sizeable numbers of Populus tremuloides present in the 1-2 and 2-3 dm dbh size classes. Interestingly, this stand has no Picea engelmannii. Ages of the four near-climax stands

range from 88 yr to 279 yr. Stand 47 has population structures of Abies lasiocarpa and Picea engelmannii quite typical of these species in climax stands. Abies nearly always has large numbers of seedlings, accounted for in large part by the layering habit of Abies, with decreasing numbers of trees in the larger size classes. Picea ordinarily has many fewer seedlings and often is represented by larger size classes than Abies. The 5 climax stands range in age from 154 yr to 365 yr and in basal area from 34.0 m^2/ha to 93.8 m^2/ha. There is a general increase in basal area from seral to climax stands.

Some of the stands sampled have overstories still dominated by Pinus contorta. There is no evidence in the White River N.F. of a h.t. dominated by Pinus contorta. All stands in which this species dominates are seral to Abies and Picea. Populus tremuloides is not an important seral species in this h.t. compared to its role in the Abies-Carex h.t. In the Routt N.F. Populus was present in only 3 of the 25 stands sampled of the Abies - Vaccinium h.t. and in 2 of the 3 stands it was present only in the seedling size class. In the White River N.F. Populus is present in 4 of the 17 stands sampled, and in 2 of these stands it is a very minor species in the seedling size class. By contrast Pinus contorta was an important seral species in 17 of the 25 stands sampled in the Routt N.F. and in 11 of the 17 stands sampled in the White River N.F. It appears to me, from observations made in both Forests, that Populus seeds or root suckers may be available to establish on most burned

Abies-Vaccinium habitats. If Populus does establish on these habitats, it is either replaced relatively soon by Abies and/or Picea, or does not develop populations comparable to its greater success on Abies-Carex habitats. It is also apparent that Pinus contorta may succeed Populus in the course of succession toward the Abies - Picea forest. The opposite trend in which Populus succeeds Pinus contorta also occurs but is not as common.

As shown in Table F the number of undergrowth species in stands of the Abies-Vaccinium h.t. range from 9 to 23. While the mean numbers of species are 15.5, 13.0, and 12.2 for seral, near-climax, and climax stands respectively, showing a general decrease in numbers, the means are not significantly different (Student's t-test) from one another. There also is a general trend of decreasing numbers of undergrowth species in older stands. For example, those stands <100 yr old have an average of 16 undergrowth species, those between 100 and 200 yr old have an average of 14.8 undergrowth species and those > 200 yr old have an average of 11 undergrowth species. Only the mean values of the youngest and oldest groups of stands are significantly different using Student's t-test. Dividing the stands into these particular age groups is arbitrary, but was done simply to examine possible trends in numbers of undergrowth species. It can be concluded that undergrowth species richness declines from seral to climax stage and from young to old stands. Another relationship of value to analyze is that of stand age to sums of coverage of undergrowth species. Using the same age

groups as above I calculated mean sums of undergrowth coverage; this was done with and without adding moss + lichen coverage values. As shown in Table 3 stands older than 200 yr have total coverage of 88.0%. This value is higher than the 56.0% for stands 100-200 yr old and 62.5% for stands $<$100 yr old. However, the mean of 88.0% is significantly different from the 56.0% only. Subtracting the coverage values for mosses + lichens lowers the totals somewhat but does not change the relative position of the stands with regard to each other. Additionally, significant differences still occur between means of coverage in stands more than 200 yr old and stands 100-200 yr old. The importance of the coverage of both *Vaccinium scoparium* and *V. myrtillus* and the importance of these species plus *Arnica cordifolia* shows two important things. First, the sums of the coverages of the Vacciniums constitutes more than 50% of the total coverage of the undergrowth. Adding the coverage of *Arnica cordifolia* increases the percentage even more. Coverage of these three species is greatest in the oldest stands, but the mean value is not significantly different from means of the younger stands. A second important point seen in the coverage data of the Vacciniums and Arnica is that these three species are present in adequate amounts in young stands as well as old stands to recognize the union. This characteristic is important as it also shows a certain level of independence of the overstory union. Stand 55 for example is essentially a *Pinus contorta* stand with just a beginning of succession toward the Abies-dominated forest, yet *Vaccinium*

Table 3. Mean sums of coverages of undergrowth vegetation in stands of the *Abies lasiocarpa* - *Vaccinium scoparium* habitat type. Mean sums are listed with and without coverages contributed by mosses + lichens. Additionally, mean sums of coverage are listed for *Vaccinium scoparium* + *Vaccinium myrtillus*. Mean coverages for *Vaccinium scoparium* + *V. myrtillus* + *Arnica cordifolia* are also given.

Stand Age in Years	Mean Number of Undergrowth Species	Percent Mean Total Coverage[a]: Mean Total with Mosses + Lichens	Percent Mean Total Coverage[a]: Mean Total without Mosses + Lichens	Percent Mean Coverage of *Vaccinium scoparium* plus *Vaccinium myrtillus*	Percent Mean Coverage of *Vaccinium scoparium* plus *Vaccinium myrtillus* plus *Arnica cordifolia*
> 200	11.2 ± 1.66	88.0 ± 11.8[b]	81.8 ± 12.1[c]	55.4 ± 13.6	59.8 ± 11.3
100 - 200	14.8 ± 2.52	56.0 ± 5.43[b]	50.6 ± 6.10[c]	36.2 ± 4.59	44.6 ± 5.52
< 100	16.0 ± 0.41	62.5 ± 7.71	61.2 ± 8.35	37.2 ± 6.86	43.0 ± 6.67

[a]These totals include the coverages of both Vacciniums + Arnica.

[b]These means are significantly different at the 0.05 probability level.

[c]These means are significantly different at the 0.05 probability level.

scoparium has a coverage of 30% and frequency of 76%. _Arnica cordifolia_ has a coverage of only 0.6% and a frequency of 6.0%. Stand 12 is also a _Pinus contorta_-dominated stand in which _Vaccinium scoparium_ has a coverage of 21% and a frequency of 88%. _V. myrtillus_ has a coverage of 0.4% and a frequency of 4.0%, and _Arnica cordifolia_ has a coverage of 3.6% and a frequency of 32%. These are seral stands; data for these are shown in Tables A and F. In these seral stands it is possible to recognize the _Vaccinium scoparium_ union, even without obtaining quantitative data. Obviously, the _Vaccinium scoparium_ union is readily recognized in climax stands. Important species of this union and their constancy values are the following:

SPECIES	CONSTANCY
Pachistima myrsinites	71%
Ramischia secunda	47%
Vaccinium myrtillus	88%
Vaccinium scoparium	100%
Carex geyeri	69%
Arnica cordifolia	94%
Pedicularis racemosa	53%

With one exception these are the same species which characterize the undergrowth of this h.t. in the Routt N.F. The exception is the greater constancy of _Pedicularis racemosa_ in the White River N.F. _P. racemosa_ is apparently even more conspicuous in subalpine forests southward. Langenheim (1962) reported it had a constancy of 97% in spruce-fir stands in the Crested Butte area. Succession following fire on the Abies-Vaccinium h.t. may or may not include _Pinus contorta_ or _Populus tremuloides_, though _Pinus contorta_ is more important than _Populus tremuloides_ as a seral

species on this h.t. In some locations on the White River Plateau and in the Holy Cross District stands of Picea and Abies are developing directly after the long-term shrub-herb seral community which established after fire. In most stands of this h.t. observed succession does include Pinus contorta.

Abies lasiocarpa - Carex geyeri h.t.--- Stands of this h.t. were sampled at elevations of 2,713 m (8,900 ft) to 2,960 m (9,710 ft). Two stands are on level sites, two are on west-facing slopes, and one is on a WNW-facing slope (Table E). Stand ages based on xylem layers at breast height range from 81 yr to 179 yr. Stand basal areas range from 40.8 m^2/ha to 82.0 m^2/ha.

Abies-Carex h.t. differs from the Abies-Vaccinium h.t. in both overstory and undergrowth vegetation though the undergrowth differences are more easily observed. In the tree layer Pinus contorta is ordinarily less conspicuous than Populus tremuloides as a seral species. Indeed, Pinus contorta is absent from the 5 stands sampled in the White River N.F. though Populus tremuloides is present in two of them. In the Routt N.F., however, P. contorta was present in 9 of the stands and P. tremuloides was present in 8 of the 11 sampled stands of this h.t.

Undergrowth vegetation of the Abies-Carex h.t. is characterized by the dominance of Carex geyeri and the numbers of species of the Thalictrum fendleri union. This contrasts with undergrowth of the Abies - Vaccinium h.t. in which Vaccinium scoparium dominates and members of the Thalictrum union are poorly represented on the whole.

The following list clarifies the point:

SPECIES	ABIES - VACCINIUM H.T. MEAN COVERAGE	CONSTANCY	ABIES-CAREX H.T. MEAN COVERAGE	CONSTANCY
Pachistima myrsinites	1.1%	71%	1.8%	40%
Ramischia secunda	0.4	47	0.5	60
Vaccinium myrtillus	5.7	88	0.1	20
Vaccinium scoparius	36.	100	0.2	20
Carex geyeri	3.6	65	14.	100
Arnica cordifolia	5.5	94	2.3	60
Aster engelmannii	0.2	18	4.1	100
Geranium richardsonii	--	--	0.8	80
Lathyrus leucanthus	2.5	41	4.6	100
Ligusticum porteri	0.1	6	2.1	100
Osmorhiza depauperata	0.3	18	1.6	80
Pedicularis racemosa	1.8	53	0.8	60
Thalictrum fendleri	--	--	4.7	40
Valeriana occidentalis	--	--	2.2	20
Vicia americana	0.3	24	0.4	40
Bromus ciliatus	+[a]	6	2.6	40
Elymus glaucus	+[a]	6	0.3	20

[a]+ = less than 0.1% mean coverage.

Presence and absence data alone would mask differences in coverage and constancy values. Most species listed occur in both h.ts., but mean coverage and constancy data distinguish the undergrowth vegetation. The Vacciniums in particular along with Arnica cordifolia are the three most abundant and commonly occurring species of the Vaccinium scoparium union. Arnica is relatively common in stands of the Abies - Carex h.t. but Vacciniums are much less important. Additionally, the Thalictrum union is represented well in this h.t. A comparison of stands of this h.t. in the White River N.F. and the Routt N.F. show both similarities and differences. The major differences in undergrowth are greater coverages of Vaccinium scoparium, Arnica cordifolia, and Elymus glaucus,

Rosa sp., and Lupinus argenteus and lesser coverages of Aster engelmannii, Geranium richardsonii, and Ligusticum porteri in stands of the Routt N.F.

Based on observations made in both the White River N.F. and the Routt N.F. it appears that the Abies - Carex h.t. develops successionally from Populus-dominated stands in which the Thalictrum fendleri union is well-represented in the undergrowth. These species linger well into the stage of Abies domination. Stands 17 and 8 are 117 yr and 81 yr old respectively and the youngest sampled of this h.t. In these stands Populus tremuloides is currently important in the overstory. These stands also have the greatest number of undergrowth species, 33 and 29 respectively. Bromus ciliatus, Elymus glaucus, Delphinium barbeyi, and Vicia americana occur only in these two stands and Geranium richardsonii reaches its greatest coverage in this h.t. in these two stands. Thalictrum fendleri has a coverage of 12% in stand 17 and is present very sparsely in stand 8. Valeriana occidentalis is present only in stand 17 where its coverage is 11%. These species, members of the Thalictrum union, disappear, or become much less conspicuous in older stands of this h.t.

A similar analysis of stand data from the Routt N.F. reveals similar relationships. Stands in which Populus tremuloides is still an important tree in the overstory also have in the understory a generally greater abundance of species of the Thalictrum union. These observations are taken as evidence of a dynamic relationship

among stands of this h.t. Stands with larger number of Populus are less mature, successionally, than those dominated by Abies and/or Picea, and the less mature stands retain more relics of the successional stage dominated solely by _Populus tremuloides_. By ignoring succession here it is possible to demonstrate an almost perfect continuum including at one extreme stands of Populus - Thalictrum vegetation and at the other extreme stands of Abies - Carex vegetation. Between the extremes one could align stands ranging from Populus-dominated vegetation with a few Abies present to Abies-dominated vegetation with a few Populus present. The undergrowth vegetation along this continuum would reveal a rich mixture of mainly herbaceous species dominated by _Thalictrum fendleri_ (referred to here as the _Thalictrum fendleri_ union) under Populus to a less rich mixture of herbs with more shrubs present and dominated by _Carex geyeri_ (referred to here as the _Carex geyeri_ union) under the Abies and Picea.

I do not conclude that all stands of Populus-Thalictrum vegetation are seral, but some are and should be recognized as such.

Following fire in the subalpine zone succession ordinarily follows one of the pathways shown in Fig. 7. This is somewhat different than that shown for secondary succession in the subalpine zone in the Routt N.F. (Hoffman and Alexander 1980). It also differs somewhat from the major trends of secondary succession according to Stahelin (1943). Following fire in the subalpine zone the early successional communities are often a mixture of heliophytic shrubs, herbs and cryptogams. In some localities this stage of succession is prolonged, for example in

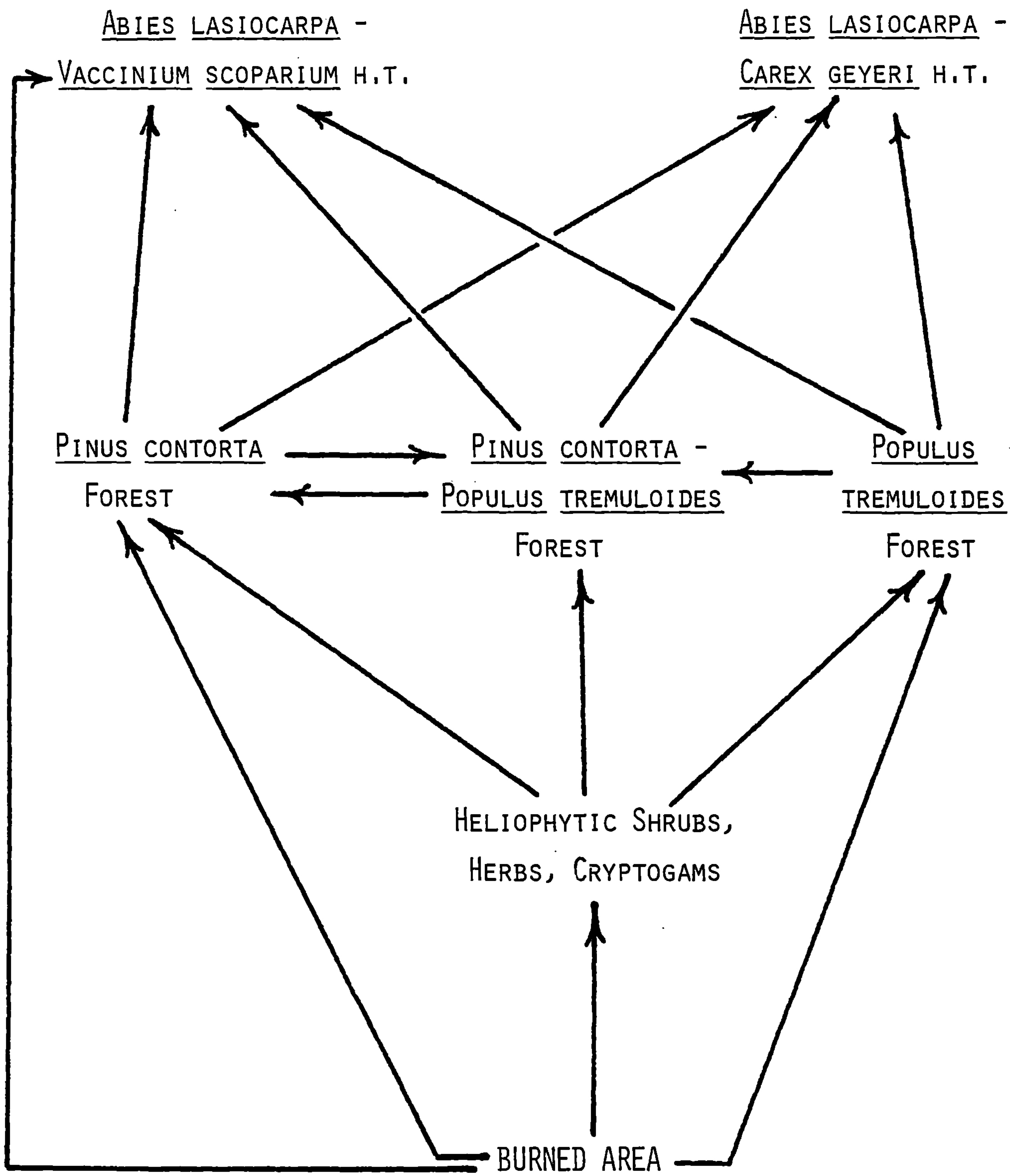


Fig. 7. Pathways of secondary succession following fire in *Abies lasiocarpa-Picea engelmannii*-dominated vegetation in the White River National Forest.

high elevation habitats of the Holy Cross District and on the White River Plateau. Apparently a lack of seed source and the severe climate conspire to slow succession after large scale fire in these areas. Where abundant seeds and/or root suckers are available, fire can be followed promptly by the appearance of aspen and/or lodgepole pine regeneration. On the other hand, in some areas spruce and fir-dominated forests develop after fire without the seral stages of lodgepole pine, or aspen. This can occur on the Abies-Vaccinium h.t. but I have not seen it occurring on the Abies-Carex h.t. There can also be some shifting of dominance within the seral communities. In the White River N.F. Pinus contorta-dominated forests may become Pinus contorta-Populus tremuloides-dominated forests, and the reverse of this also happens with Pinus-Populus-dominated forests becoming Pinus-dominated forests. With regard to Populus tremuloides-dominated forests, however, they may add Pinus contorta before succession is completed but I have not seen Pinus-Populus-dominated forests lose the Pinus before succeeding to Abies-dominated forests. In the case of succession on Abies - Carex h.ts. most stands examined show evidence of going directly from the Populus-dominated vegetation to the Abies-dominated vegetation.

Edaphic factors measured are similar for surface soils of the Abies-Vaccinium and the Abies-Carex h.ts. (Table G). Indeed, the only factor measured for which there is a statistically significant difference is calcium content. The means and standard errors are 1960 $\pm$ 152 ppm and 936 $\pm$ 123 ppm for the

Abies-Carex and Abies-Vaccinium h.ts. respectively. It is interesting that the older stands of the Abies-Carex h.t., numbers 48, 43, and 44, also have lower soil calcium content. This is not unexpected in terms of podsolization occurring over a longer time and leaching more basic cations from the surface soils. The same trend is not as evident for soils of the Abies-Vaccinium h.t. Here the oldest stands are numbers 51, 22, 23, 47, and 45. Soil calcium contents are 657 ppm, 758 ppm, and 505 ppm for stands 51, 23 and 47 respectively. The value for stands 22 and 45 are 2,172 ppm and 1,566 ppm Ca respectively. Additionally, young stands have soils with quite low calcium content. Stands 28 and 13 are each 85-90 years old and their soils have 606 ppm and 657 ppm calcium respectively. While there is a significant difference in the mean soil calcium content between the Abies-Carex and Abies-Vaccinium h.ts. the source of variability within each h.t. may be related to age of stands in the Abies-Carex h.t. but is unknown for stands of the Abies-Vaccinium h.t. The Abies-Carex h.t. exhibits in its development stands of <u>Populus</u> <u>tremuloides</u>- dominated vegetation to a much greater extent than the Abies-Vaccinium h.t. This provides a plausible basis on which to explain larger concentrations of calcium in soils of the Abies-Carex h.t. and perhaps the decline in calcium content as the stands age. It may also be pertinent that Bartos and DeByle (1981) reported in northern Utah that aspen leaf litter contributed about 30 kg/ha of Ca each year. This compares with their data of 8 kg/ha nitrogen, 1 kg/ha phosphorous, 7 kg/ha potassium and 2 kg/ha magnesium.

This would insure a rather constant and sizeable input of calcium into the substrate of aspen stands until the aspen were replaced successionally by other species.

The edaphic similarities between these two h.ts. are considerably greater than the differences, and the major difference measured, calcium content, may have little influence as an intrinsic habitat factor in ultimately distinguishing the Abies-Carex h.t. from the Abies-Vaccinium h.t. This is unknown.

Other Vegetation Types

Quercus gambelii - Symphoricarpos oreophillus h.t.---Owing to time constraints I sampled no stands of the Quercus - Symphoricarpos h.t. quantitatively but visited a number of stands and qualitatively evaluated them with notes on both overstory and undergrowth vegetation. This h.t. occupies a somewhat xeric zone frequently between the Populus tremuloides zone above and the Pinus edulis zone below (Fig. 6). The Quercus zone may also contact the Artemisia tridentata on its lower or upper margins (Figs. 4, 5), and in some places the reversed zonation places the Populus zone below the Quercus zone (Fig. 4). Irrespective of its position relative to other vegetation Quercus - Symphoricarpos is more xerophytic than Populus-dominated vegetation and more mesophytic than Pinus edulis-dominated vegetation.

Climatic data from Meeker, Rifle, Silt and Glenwood Springs may be somewhat characteristic of the Quercus zone (Table 1).

This habitat type is well-developed in the southwestern corner of the Forest where it covers many hectares of low hills. Southward into the Gunnison N.F. and the Grand Mesa N.F. it appears to me that Quercus-dominated vegetation becomes more important as part of the total vegetation. It is present also in other low elevation locations over much of the White River N.F. Both Amelanchier alnifolia and Prunus virginiana are important shrubs in this h.t. as they were in the Routt N.F.

The Symphoricarpos oreophilus union is present under Quercus in much the same composition as it is under Populus in somewhat

more mesic habitats. There are some floristic differences under Quercus; _Wyethia amplexicaulis_ and _Balsamorhiza sagittata_ are conspicuous additions in the more open areas and, in the case of Wyethia, in more heavily grazed areas. Additionally, _Artemisia tridentata_, which is a dominant of the shrub-steppe below the Quercus zone (Fig. 2), frequently occurs in open areas of the oak thickets. Grazing is intense over parts of the Quercus zone.

Pinus edulis-dominated vegetation.---_Pinus edulis_, along with _Juniperus osteosperma_, _J. scopulorum_, and _J. monosperma_ dominate this xerophytic vegetation at low elevations. This piñon-juniper vegetation is more important south and west of the White River N.F. though in this region it forms a discontinuous belt along the lower margin of the forest. It is rather well-represented along the lower western edge of the White River Plateau and southward. It also occurs south and east of Glenwood Springs primarily in all situations below the boundary of the National Forest. Discontinuous stringers of it also extend northward and end just south of Yampa.

Lack of sufficient time prevented my giving adequate attention to stands of this broad vegetation type to discern the habitat types, though I examined several stands of this vegetation all of which occur on rocky slopes with very shallow soils. All are at relatively low elevation, from 1,860 m (6,100 ft) to 2,012 m (6,600 ft). Dominance is shared in numerous stands by Pinus and Juniperus, and both are represented by several size classes up to and including 3 - 4 dm dbh. In some stands there are individuals in the 4 - 5 dm dbh size size class. I calculated

basal areas for only four stands and the values range from 17.2 m^2/ha in a stand in which most of the dominants were in the 0-1 dm dbh size class to 53.6 m^2/ha in which most of the dominants are between 1 - 2 dm and 3 - 4 dm dbh. In some stands Juniperus is far more abundant than Pinus. Along the west side of the White River plateau south of Meeker the lower margin of this vegetation type contacts Artemisia tridenta-dominated shrub-steppe. These low elevation stands are dominated by Juniperus which appears to be moving into the shrub-steppe below. Higher on these steep west-facing slopes the composition of the stands shifts to include more Pinus edulis. Also, higher on the slopes the substrates become much more rocky with very shallow soils in comparison to the deeper soils of the Artemisia shrub-steppe. This entire fringe of Pinus - Juniperus vegetation extending south of Meeker, then eastward toward Newcastle and Glenwood Springs and beyond and south again toward Aspen is entirely below the Forest boundary.

The undergrowth in stands of Pinus - Juniperus vegetation is variable and in places is extremely sparse. Both herbaceous and woody species are present. Some of the more conspicuous species are the following:

Artemisia tridentata	Bromus tectorum
Rhus aromatica	Agropyron smithii
Chrysothamnus nauseosus	Oryzopsis sp.
Atriplex canescens	Haplopappus spp.
Philadelphus microphyllous	Senecio integerrimus
Cercocarpus montanus	Sphaeralcea coccinea
Festuca idahoensis	Eriogonum umbellatum
Stipa comata	Cryptantha sp.
Bouteloua gracilis	Astragalus sp.

In a large proportion of the stands surface rock constitutes nearly 50% of the ground surface and lichens may cover about half the rock surface. Some of this vegetation type has been grazed heavily. In certain places deer pellets are very common indicating considerable use by deer in this region.

During the last century piñon pine was cut for use as railroad ties, and junipers were commonly used for fence posts (Sudworth 1898).

The Pinus - Juniperus vegetation is a very minor component of the total vegetation in the White River N.F. and does not occur within the Routt N.F. South and west of the region it becomes a very conspicuous feature of the landscape and to date little has been done to describe and characterize the habitat types or the dynamics of the vegetation.

Pinus ponderosa, as in the Routt N.F., is a very minor species in the White River N.F. An occasional old specimen occurs in stands of *Pseudotsuga menziesii* - *Pachistima myrsinites* h.t. Others are present in obviously disturbed habitats on steep rocky slopes. There are no stands of *Pinus ponderosa* here. According to Sudworth (1898) there were once stands of *P. ponderosa* along the White River, South Fork of the White River, and Canyon Creek as well as a few other streamsides. However, a combination of logging and fire served to decimate the few stands that were present and even as early as the late 1800's only a few lone trees were to be found (Sudworth 1898).

Picea pungens occurs along streams over much of the southern half of the White River N.F. It is confined to narrow streamside

terraces and extends upslope short distances in narrow canyons. It occurs along the Eagle, Colorado, Roaring Fork and Frying Pan Rivers and along some smaller streams, Brush Creek, Rifle Creek, Grizzly Creek and others. Most stands apparently have been disturbed. Numerous roads that follow streams have altered the streamside habitats and campgrounds, off road parking and fishermen have all contributed to disturbing habitats dominated by *Picea pungens*. In many places only a few scattered trees have been left and these are surrounded by rank growth of heliophytic shrubs and herbs. The undergrowth is highly variable from place to place along streams where Picea still remains. Both *Pseudotsuga menziesii* and *Populus tremuloides* occur in some stands with *Picea pungens*. In narrow steep-walled canyons where *Picea engelmannii* - *Abies lasiocarpa*-dominated vegetation extends downward to relatively low elevations there may be a mingling of this vegetation with *Picea pungens*-dominated vegetation. The possibility of hybridization between the Piceas exists in these locations.

Some of the more conspicuous undergrowth plants in stands of *Picea pungens* include the following:

Amelanchier alnifolia	*Galium boreale*
Mahonia repens	*Lathyrus leucanthus*
Rubus parviflorus	*Osmorhiza sp.*
Symphoricarpos oreophilus	*Senecio wootoni*
Rosa spp.	*Vicia americana*
Pachistima myrsinites	*Carex geyeri*
Achillea millefolium	*Carex spp.*
Fragaria sp.	*Bromus ciliatus*
Geranium richardsonii	*Poa spp.*

The possibility of *Picea engelmannii* x *Picea pungens* hybrids was given brief consideration. I made 21 collections

of Picea cones from locations ranging in elevation from 2,210 m (7,250 ft) to 3,353 m (11,000 ft). I used a somewhat modified method outlined by Daubenmire (1968b,1972), as indicated above, to determine a hybrid index number for each cone of each collection. The data are summarized in Table 4. As shown, there is little or no evidence, based on measured cone characteristics, of hybridization between the two spruces in this study. In general, spruces at lower elevations along streams have cone characteristics quite distinct from those of spruce at higher elevation. The latter keyed to *Picea engelmannii* with little difficulty. The only collections that appear to be intermediate, and not exhibiting strongly the characteristics of either species, are numbers 9 and 10. Collection 9, from the Carbondale District south of Glenwood Springs, was made at an elevation of 9,225 ft (2,812 m) intermediate between sites where the spruces are more distinctly one species or the other. Collection 10 from middle Thompson Creek road, also south of Glenwood Springs, was made at an elevation of 9,650 ft (2,941 m). Cone data from these two sites are insufficient to indicate certainly whether hybridization is occurring between the spruces. The measurements and calculations show a definite intermediate position for these spruces, and it is not impossible the samples represent hybrids. For this study, however, I consider these particular samples to be *Picea engelmannii*. More samples in this area might clarify the possibility of hybridization. There is no evidence for introgression in any of the samples collected. Piceas in stands of the Abies - Vaccinium and Abies - Carex h.ts. are quite clearly *Picea engelmannii*. *Picea pungens* occupies a quite

limited area of the White River N.F. and its identification poses no problem. I did not find it in stands with Picea engelmannii in this region. This would seemingly be of some advantage to individuals requiring identification of spruces in this region. Picea pungens - dominated h.ts. were not reported for the Crested Butte area (Langenheim 1962) to the immediate south of the White River N.F. nor for the San Juan Mountains (Steen and Dix, cited by Alexander (1974). In Arizona and New Mexico, however, Moir and Ludwig (1979) reported 5 h.ts. in which Picea pungens was dominant or shared dominance with other tree species.

Pinus flexilis is reported in the older literature to have occurred in scattered locations in the White River N.F. I saw none in any areas I visited in this region.

Table 4. Numbers of cones showing hybrid index values for Picea cone collections. The high values representative of Picea pungens are quite distinct from the low values representative of P. engelmannii. Only collections 9 and 10, from sites of intermediate elevation, show intermediate index values. Numbers in parentheses are cones collected per site.

			Hybrid Index Numbers												
Number	Location	Elevation	0	1	2	3	4	5	6	7	8	9	10	11	12
1	Along West Brush Ck south of Eagle (15)	7700' (2347m)									2	2	8	1	2
2	North side of Reudi Reservoir (12)	7900' (2408m)								3	2	3	3	1	
3	Road 300, south of Glenwood Springs (10)	8225' (2507m)									3	2	5		
4	Along Eagle River near Eagle (9)	7250' (2210m)							2	2	2	2	1		
5	Along Frying Pan River east of Basalt (13)	8650' (2637m)							1	1	6	2	3		
6	Along Road 105 east of Basalt (8)	8700' (2652m)							1	3	1	2	1		
7	Along Road 105 east of Basalt (11)	8650' (2637m)							6	3	2				
8	Along Frying Pan River east of Basalt (11)	8650' (2637m)						2	4	1	4				
9	Road 300 south of Glenwood Springs (10)	9225' (2812m)					1	6	3						
10	Middle Thompson Creek Road south of Glenwood Springs (10)	9650' (2941m)					2	6	2						

Table 4, cont'd.

			Hybrid Index Numbers												
Number	Location	Elevation	0	1	2	3	4	5	6	7	8	9	10	11	12
11	Woody Creek Road east of Aspen (10)	10,300' (3139m)				2	3	3	2						
12	Klinetops north of Newcastle (12)	9375' (2858m)			1	1	5	4	1						
13	Crooked Pass south of Eagle (16)	9750' (2972m)			7	5	3	1							
14	Lime Creek Road west of Vail Pass (7)	11,000' (3353m)			1	3		3							
15	Buford Road (11)	9350' (2850m)		3	4	2	1	1							
16	Woody Creek Road east of Aspen (15)	10,000' (3048m)		1	6	5	2	1							
17	Woody Creek Road east of Aspen (9)	9750' (2972m)				4	5								
18	Pine Creek Road north of Vail (10)	9700' (2957m)		3	5	1	1								
19	North Fork Frying Pan River east of Basalt (7)	9350' (2850m)		1	3	2	1								
20	Sandstone Creek Road north of Vail (13)	10,000' (3048m)	2		8	1	2								

Distribution and Dynamics of Forest Tree Species

The most widely distributed tree in this study is Populus tremuloides. It is both seral and climax, judging from analysis of tree population data in numerous stands. Populus reaches its maximum abundance at elevations of about 2,600 m (8,530 ft) to 3,050 m (10,006 ft). Most of the stands sampled occur between 2,650 m (6,695 ft) and 2,900 m (9,514 ft). All stands of the Populus - Carex h.t. occur from 2,972 m (9,750 ft) to 3,033 m (9,950 ft). There is no important seral tree species in Populus-dominated h.ts. Occasionally there are a few Abies lasiocarpa but these are not yet indicative of a successional trend.

Populus is an important seral species in the subalpine zone where, following fire, it develops temporary forests. It is often accompanied by Pinus contorta as a seral species. Pinus contorta is a more important seral species in the Abies lasiocarpa - Vaccinium scoparium h.t. while Populus tremuloides is a more important seral species in the Abies lasiocarpa - Carex geyeri h.t. The dynamic status of Populus tremuloides in the Rocky Mountains has been the subject of spirited debate for many years. Fetherolf(1917) maintained that aspen is a permanent type in southern Utah, and probably elsewhere, and that conifers cannot readily become established under aspen. This generalization applies to a zone between the subalpine above and the more xeric pine- and chaparral-dominated zones below. South of Pike's Peak Gardner (1905) observed aspen became established after fires

nearly in conjunction with conifers, particularly Picea engelmannii. He considered aspen to be a temporary species. Dixon (1935) could not decide, from her observations in Utah whether aspen is seral or climax or both. Baker (1925) considered aspen to be generally a seral species, though he conceded that in places it has the characteristics of a permanent type and should be managed as such. He did not grant climax status to aspen. In recent studies in western Wyoming (Youngblood and Mueggler 1981) and southeastern Idaho (Mueggler and Campbell 1982) aspen-dominated vegetation is named community types conforming to the authors' view that aspen is not a climax species or if it is the terminology can be changed accordingly. Reed (1971) did describe one aspen-dominated habitat type in the Wind River Mountains. Our data and observations from the Routt N.F. (Hoffman and Alexander 1980) and the White River N.F. indicate aspen is climax over part of its range, and also a seral species in this region.

Picea engelmannii and Abies lasiocarpa dominate vegetation of the subalpine zone. Neither species is important as a seral species in other vegetation zones. An occasional Abies occurs in Populus-dominated vegetation, as indicated above. Succession involving spruce and fir vegetation is diagrammed in Fig. .

Pinus contorta is an important seral species in the Abies lasiocarpa - Vaccinium scoparium h.t. It is rare in the Abies lasiocarpa - Carex geyeri h.t. and in all the Populus tremuloides-dominated h.ts. Additionally, it forms no climax stands in the White River N.F. These observations stand in contrast to its

role in the Routt N.F. where it is a climax species over a limited segment of its range and is an important seral species over much of the subalpine zone. It occurs also in numerous stands of Populus tremuloides (Hoffman and Alexander 1980). In the Crested Butte area to the south Langenheim (1962) found Pinus contorta to occur on burned areas principally on north slopes on granitic or coarse clastic substrates and at elevations of 9,500 ft (2,896 m) to 10,500 ft (3,200 m). There it is also a seral species. In the Medicine Bow Mountains Pinus contorta is an important seral species in the Abies lasiocarpa - Vaccinium scoparium h.t. and the Abies lasiocarpa - Carex geyeri h.t. It also occurs occasionally in stands dominated by Populus tremuloides, Pinus flexilis, and Pinus ponderosa (Wirsing and Alexander 1975).

Pseudotsuga menziesii occupies a restricted area below or above the Populus zone, depending on microclimatic conditions. It is not an important seral species in Populus tremuloides-dominated h.ts. in the White River N.F. though it forms a fragmentary zone in close proximity to the Populus zone and it is more abundant than in the Routt N.F.

Pinus ponderosa is rare though an occasional old specimen occurs in stands of Pseudotsuga menziesii- or Quercus gambelii-dominated vegetation. As indicated above Pinus ponderosa was heavily logged during the 1800's and the small volume that was present initially was nearly depleted by the logging and also burning.

Quercus gambelii occupies xeric habitats in a zone below the Populus tremuloides zone. It often occurs above or below

the Pinus edulis - Juniperus spp. zone. Indeed, depending on slope and exposure it may occur above Populus tremuloides (Fig. 4). Unlike the distribution in the Routt N.F., Quercus gambelii and Populus tremuloides develop fewer stands in which the two species coexist. Moisture may be a more limiting factor in the White River N.F. and where Quercus is abundant in the southwestern part of the Forest, there is little Populus.

Pinus edulis and Juniperus spp. have a limited distribution in the White River N.F. Most stands dominated by these species occur below the lower boundaries of the forest. Though I spent less time examining stands of piñon-juniper than any other vegetation types in this study, it did not appear that either piñon or juniper move upslope into Quercus gambelii- or Populus tremuloides- dominated vegetation or onto their h.ts. after sites have been disturbed. The only exception to this is an occasional specimen of Juniperus scopulorum occurring in stands of Pseudotsuga or Quercus.

The distribution and roles of tree species in this study are shown in Fig. 8.

Habitat Type \ Species	*Pinus edulis*	*Juniperus scopulorum*, *J. osteosperma*, *J. monosperma*	*Quercus gambelii*	*Pinus ponderosa*	*Pseudotsuga menziesii*	*Populus tremuloides*	*Pinus contorta*	*Abies lasiocarpa*	*Picea engelmannii*	*Picea pungens*
Pinus edulis - *Juniperus spp.*	C	C								
Quercus gambelii - *Symphoricarpos oreophilus*		o	C	o	o					
Pseudotsuga menziesii - *Pachistima myrsinites*		o		o	C	o		o	o	
Populus tremuloides - *Symphoricarpos oreophilus*						C		o		
Populus tremuloides - *Pteridium aquilinum*						C		o		
Populus tremuloides - *Heracleum sphondyllium*						C		o		
Populus tremuloides - *Thalictrum fendleri*						C		o	o	
Populus tremuloides - *Carex geyeri*						C		o		
Abies lasiocarpa - *Vaccinium scoparium*					o	s	S	C	C	
Abies lasiocarpa - *Carex geyeri*						S	s	C	C	
Picea pungens - dominated h.ts.					o	o				C

Fig. 8. The ecologic roles of tree species in habitat types of the White River National Forest. C = Climax; S = Major Seral; s = minor seral; o = occasional.

Species Richness

Undergrowth species richness ranges from a total of 27 in the Populus tremuloides - Heracleum sphondyllium h.t. to 73 in the Populus tremuloides - Thalictrum fendleri h.t. Median values are lower and are presented in Table 5. As shown, species richness based on median values is greatest in the Populus tremuloides - Symphoricarpos oreophilus and Populus tremuloides - Thalictrum fendleri h.ts. The Populus - Pteridium h.t. has 35 species, but only one stand was sampled. However, this h.t. also has a high species richness in the Routt N.F. As in the Routt N.F., the Populus - Heracleum h.t. in the White River N.F. has the lowest number of species among the Populus-dominated h.ts. The dominant Heracleum shades the forest floor and promotes a microclimate which permits only the most shade tolerant among the undergrowth species to survive. Only 27 total undergrowth species were sampled in the Populus-Heracleum h.t. in this study. It is interesting that for h.ts.

Table 5. Species richness of undergrowth vegetation in habitat types of the White River National Forest.

Habitat Type	Median Number[a] of Undergrowth Species	Number of Stands Studied
Pseudotsuga menziesii - Pachistima myrsinites	21	2
Populus tremuloides - Symphoricarpos oreophilus	27	8
Populus tremuloides - Thalictrum fendleri	26	12
Populus tremuloides - Pteridium aquilinum	35	1
Populus tremuloides - Heracleum sphondyllium	20	2
Populus tremuloides - Carex geyeri	21	4
Abies lasiocarpa - Vaccinium scoparium	16	17
Abies lasiocarpa - Carex geyeri	22	5

[a]Based on 125 m^2 per stand

which occur in both the White River N.F. and Routt N.F. median numbers of undergrowth species are quite similar. The greatest difference is found in the Pseudotsuga - Pachistima h.t. in which the median is 21 species in the White River N.F. and only 8 in the Routt N.F. The Populus - Carex h.t. has 21 undergrowth species; this low number reflects edaphic characteristics and slope exposure. As shown in Table 2, soils of the Populus - Carex h.t. have significantly less calcium, nitrogen, organic matter, and phosphorous than soils of either the Populus - Thalictrum or the Populus - Symphoricarpos h.ts. In addition all four stands of the Populus-Carex h.t. are on south-facing slopes which presumably are more xeric than normal for the elevational range at which they occur. Wirsing and Alexander (1975) also found Populus - Carex stands on south-facing slopes in the Medicine Bow N.F.

In the subalpine zone species richness in the Abies-Vaccinium and Abies - Carex h.ts. is 16 and 22 respectively. These numbers compare to 15 and 20 for these same h.ts. in the Routt. The close correspondence of these numbers is interesting and of value as another indication of the integrity of these habitat types as they occur over a considerable geographic region.

Regarding tree species richness, Abies - Vaccinium and Abies-Carex h.ts. had 5 and 4 species respectively. The Pseudotsuga - Pachistima h.t. had 6 species. These numbers all include the occasional species. Tree species richness is least in the lower, xeric habitat types dominated by piñon and junipers

and also over most of the Populus tremuloides zone where Populus and occasionally Abies are the only two species. Rarely, Picea engelmannii also occurs in an aspen stand. Tree and undergrowth species richness tend to complement one another. In habitat types where undergrowth species richness is relatively low, Pseudotsuga- and Abies-dominated h.ts., tree species richness is high. Where undergrowth species richness is relatively high, as in Populus-dominated h.ts., tree species richness is low.

Another observation involves shrub species richness. Populus-dominated h.ts., except for Populus - Symphoricarpos, are notably rich in herbaceous species and poorer in shrub species. Even Populus - Symphoricarpos stands have considerably fewer shrubs than stands of the Abies - Vaccinium and Abies - Carex h.ts. As in the Routt N.F. I found distinct differences in shrub species richness between Abies- and Populus-dominated h.ts. in the White River N.F. The differences in the White River N.F. are shown below:

Habitat Type	Median Number of Shrub Species per Stand	Total Number of Shrub Species Encountered
Populus tremuloides - Thalictrum fendleri	2	8
Abies lasiocarpa - Vaccinium scoparium	5	14

The total shrub species of these two h.ts. is greater in the Routt N.F. but the median values are very much the same. In the Routt N.F. the median values were 2 and 6 respectively for the Populus - Thalictrum and Abies - Vaccinium h.ts. and the total shrub species were 12 and 21 respectively.

SOME PRACTICAL CONSIDERATIONS AND FURTHER STUDIES

From a basic ecologic viewpoint, the habitat type approach provides a natural system of classifying landscapes based on vegetation potential of the landscape. The fact that stands of seral vegetation are related in a developmental sequence to particular climax communities offers the possibility of referring stands of seral vegetation to the potential vegetation (biotic potential) for each of these stands. From the management viewpoint this would appear to offer numerous possibilities. Some of these possibilities have been explored by others. Daubenmire (1961) found that growth rates of *Pinus ponderosa* differ on different habitat types. He also found in the same study that Arceuthobium establishes on *Pinus ponderosa* on sites of the *Pinus ponderosa* - *Agropyron spicatum* h.t. and *Pinus ponderosa* - *Purshia tridentata* h.t. but not on pines of other Pinus-dominated h.ts. in his study region. These characteristics cannot be predicted; they must be determined by field studies and observations. So far no studies have examined the possibility of different growth rates of *Populus tremuloides* or *Picea engelmannii*

or Abies lasiocarpa of different h.ts. in which these species are important. Neither have studies been done to determine if there are important differences in reproductive capacity of these tree species on different h.ts. A preliminary examination of the data suggests that reproduction of Populus is adequate throughout stands of the Populus series though occasional stands occur in which seedlings are much reduced in number. A more detailed study may reveal whether large differences in seedling numbers are peculiarities of individual sites only or whether such differences are more related to h.ts. It may be neither and other factors such as grazing may influence the sprouting habit of Populus, as others have suggested. The importance of Pinus contorta in the Abies - Vaccinium h.t., as compared to its importance in the Abies - Carex h.t. is noteworthy. This difference might relate to edaphic factors. In this study, among the factors measured, only calcium content of the upper dm of mineral soil differed significantly between the Abies - Vaccinium and Abies - Carex h.ts. Possibly factors not measured are important here. There are considerable differences in numbers of Abies seedlings which may relate to the layering habit of Abies.

From the grazier's viewpoint it may be of interest to know what differences there are in undergrowth production among Populus-dominated habitat types. An early study by Ellison and Houston (1958) found production of vegetation under Populus to be an indicator of production of adjacent openings. Nothing in

their study concerned habitat types. Cattle and sheep grazing are widespread in the White River N.F. If important differences among h.ts. are related to grazing and its effects, these should be known to resource managers.

The field of game management would seemingly benefit from a knowledge of h.ts. and their potential in providing food and shelter to animal species.

Finally, Shepherd (1959) indicated a possible relationship of susceptibility of *Picea engelmannii* to insect infestation and habitat types.

KEY TO THE HABITAT TYPES OF THE WHITE RIVER NATIONAL FOREST

1. Deciduous trees dominant and reproducing; conifers may be present but are ordinarily rare and are not reproducing sufficiently to become dominant.

    2. _Quercus gambelii_ dominant; other tree species absent or not dominant
    .... QUERCUS GAMBELII - SYMPHORICARPOS OREOPHILUS H.T.

    2. _Quercus gambelii_ absent or not dominant; _Populus tremuloides_ dominant

        3. Undergrowth dominated by _Symphoricarpos oreophilus_
        .... POPULUS TREMULOIDES - SYMPHORICARPOS OREOPHILUS H.T.

        3. Undergrowth dominated by rich mixture of herbaceous plants; _Symphoricarpos oreophilus_ may be present but is not dominant.

            4. Undergrowth dominated by _Pteridium aquilinum_
            .... POPULUS TREMULOIDES - PTERIDIUM AQUILINUM H.T.

            4. _Pteridium aquilinum_ may be present in the undergrowth but is not dominant

                5. Undergrowth dominated by _Heracleum sphondyllium_
                POPULUS TREMULOIDES - HERACLEUM SPHONDYLLIUM H.T.

                5. _Heracleum sphondyllium_ may be present in the undergrowth but is not dominant

                    6. Undergrowth dominated by _Carex geyeri_; _Arnica cordifolia_ may also be important. Undergrowth may be a rich mixture of species, but _Thalictrum fendleri_, _Aster engelmannii_, _Geranium richardsonii_, and _Ligusticum porteri_ are usually absent or not abundant
                    .... POPULUS TREMULOIDES - CAREX GEYERI H.T.

                    6. _Carex geyeri_ present in the undergrowth ordinarily; but the rich undergrowth is dominated by _Thalictrum fendleri_ with considerable coverage provided by _Aster engelmannii_, _Geranium richardsonii_, and _Ligusticum porteri_
                    ..POPULUS TREMULOIDES - THALICTRUM FENDLERI H.T.

1. Deciduous trees may be present but are neither dominant nor reproducing sufficiently to maintain their populations. Conifers dominant and reproducing satisfactorily

7. *Pseudotsuga menziesii* dominant and reproducing; other conifers may be present but are occasional or rare and are not reproducing in sufficient numbers to maintain a population
   .... PSEUDOTSUGA MENZIESII - PACHISTIMA MYRSINITES H.T.

7. *Pseudotsuga menziesii* absent or rare or occasional and not reproducing. *Abies lasiocarpa* and/or *Picea engelmannii* dominant and reproducing. *Pinus contorta* may be an important member of the overstory

   8. Undergrowth dominated by *Vaccinium scoparium*
      .... ABIES LASIOCARPA - VACCINIUM SCOPARIUM H.T.

   8. *Vaccinium scoparium* may be present but is not dominant; the undergrowth dominated by *Carex geyeri*
      .... ABIES LASIOCARPA - CAREX GEYERI H.T.

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APPENDIX

Table A. Tree population structures of each species in each stand listed by habitat types. Numbers of trees listed are per 375 m^2; basal areas (b.a.) in m^2/ha are given below stand numbers. Abbreviations of tree species are as follows:

Ps m --- *Pseudotsuga menziesii*
Po t --- *Populus tremuloides*
Pn c --- *Pinus contorta*
Pc e --- *Picea engelmannii*
Ab l --- *Abies lasiocarpa*
Ju s --- *Juniperus scopulorum*

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm: 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
		Populus tremuloides - *Symphoricarpos oreophilus* h.t.									
4 22.5	Po t		13	15	4	2	1				
10 49.9	Po t	7			16	8	2				
49 25.5	Po t	51	62	32	3	1					
6 56.1	Po t	30	56	3	3	22	8	1			
	Ab l		1								
7 57.7	Po t	266	9	10	9	11	2				
37 32.3	Po t	225	78	5	9	14	3				
38 41.8	Po t	37	4	19	25						
19 48.7	Po t	45	6	74	10						
		Populus tremuloides - *Pteridium aquilinum* h.t.									
14 29.3	Po t	240	9	6	7	6					

Table A, cont'd.

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm: 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
		Populus tremuloides - Thalictrum fendleri h.t.									
2 43.6	Po t	480	3	12	17	5					
3 54.9	Po t	60	2	3	3	11	5				
11 44.7	Po t	195	12	28	20	2					
	Ab l	2									
16 46.9	Po t	180	15	1	2	16					
34 31.2	Po t	15	20	20	5	5					
24 44.8	Po t	60	2	40	13	3					
15 56.1	Po t	15	1	6	25	8					
5 45.3	Po t	90	8	13	27	1					
	Ab l		3								
53 43.4	Po t	94		1	6	7	1	2			
	Ab l	2									
39 68.2	Po t	412	49	10	11	6	4	1			
40 68.6	Po t	488	51	7	6	6	4	1	1		
18 42.9	Po t	15	1	6	9	11					

Table A, cont'd.

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm 0-1 <.5	 >.5	 1-2	 2-3	 3-4	 4-5	 5-6	 6-7	 7-8	 8+
		Populus tremuloides - Heracleum sphondyllium h.t.									
35 48.5	Po t	60	20		4	11	3				
54 24.5	Po t	188			14	3					
		Populus tremuloides - Carex geyeri h.t.									
25 37.7	Po t	240		15	19	1					
26 26.4	Po t	60	1	14	13	1					
27 38.3	Po t	128	11	28	11	3					
41 47.0	Po t	345	7	18	9	9					
	Ab l		1								
		Pseudotsuga menziesii - Pachistima myrsinites h.t.									
36 30.4	Ps m	15	7	30	11						
	Pc e	5		2							
	Ju s		1								
57 31.4	Ps m	20	4	12	12	3					
	Ab l			1							
	Ju s	16	2	2							
		Abies lasiocarpa - Carex geyeri h.t.									
48 82.0	Ab l		5	2	2	1	1				
	Pc e		1	1	2	5	4		1	1	1
17 52.1	Ab l	116	15	6					1		
	Pc e		2								
	Po t			9	10	6	1				

Table A, cont'd.

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm: 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
43 73.8	Ab l	120	4	3							
	Pc e	15	2	10	2	9	7	2			
44 44.9	Ab l	165	9	4	1						
	Pc e	30	2	5	1	1	5	2			
8 40.8	Ab l	34	16	8							
	Po t	30	9	16	14	3					
			Abies lasiocarpa - *Vaccinium scoparium* h.t.								
9 68.8	Ab l	210	15	10	4	4	1				
	Po t			31	21						
50 32.0	Ab l	150	1	1		2					
	Pc e	30			1						
	Pn c			7	11	1	1				
51 75.9	Ab l	120	4	6	1	2					
	Pc e	32		2	4	7	5	3			
1 34.0	Ab l	227	6	7	11						
	Pc e	29	9	4	7	1					
55 28.1	Ab l	7									
	Pn c	3	6	22	13						
	Po t	1									
12 40.5	Pc e	7									
	Pn c	12	3	20	15	4					
	Po t	1	3	1							

Table A, cont'd.

Stand and b.a.	Spp.	0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
28 40.2	Pc e	10	1	5	2						
	Ab l	18	7	1	1						
	Pn c	3	3	10	17	2					
13 29.3	Pn c	19	15	6	7	6					
42 38.9	Ab l	23									
	Pn c	4	2	2	9	10					
	Po t	1									
22 84.7	Ab l	60	25	38	7	4	2				
	Pc e	90	8	28	2			3			
23 81.9	Ab l	217	9	5	2		1				
	Pc e	20	5	9	1	1	1	6	1	1	
47 52.1	Ab l	322	8	5	1	3					
	Pc e	28	1	1	2	1			1		
	Pn c					4	3				
46 63.0	Ab l	3									
	Pc e	10		2	1	1					
	Pn c	1	7	16	21	7	1				
52 46.5	Ab l	6	2	1							
	Pc e	12		1							
	Pn c		4	20	23	2					
21 56.5	Ab l	310	7	6	3						
	Pc e	56	14	23	10						
	Pn c	1	1	3	4	3	2				

Diameter (at breast height) classes in dm

Table A, cont'd.

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm									
		0-1		1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
		<.5	>.5								
20 56.4	Ab l	30									
	Pc e	15				1					
	Pn c	2	7	16	12	5	4				
45 93.8	Ab l	46	1	2	1	1					
	Pc e	15		2	3	8	7	2	1	1	

Table B. Coverage (C) and frequency (F) of undergrowth species in stands of *Populus tremuloides* - *Symphoricarpos oreophilus*, *Populus tremuloides* - *Heracleum sphondyllium*, and *Populus tremuloides* - *Carex geyeri* habitat types. Coverage of less than 0.5% is indicated by +. Stand numbers, locations, and topographic positions are also given.

	Populus - *Symphoricarpos* h.t.							*Populus* - *Heracleum* h.t.			*Populus* - *Carex* h.t.			
Stand Number	4	10	49	6	7	37	38	19	35	54	25	26	27	41
Location:														
Section	6	34	32	11	11	8	5	24	30	17	14	14	10	26
Township	4S	3S	1S	11S	11S	8S	8S	5S	4S	7S	8S	8S	8S	6S
Range	91W	92W	91W	89W	89W	83W	83W	82W	90W	83W	83W	83W	83W	83W
Topo. Position:														
Slope, %	25	--	--	--	--	34	30	30	22	42	38	38	30	43
Aspect, ^{o}	85	--	--	--	--	266	82	66	156	154	174	176	180	170
Elevation, m	2652	2752	2667	2774	2774	2758	2858	2591	2713	2957	2975	2975	3033	2972
Coverage, % / Frequency, %	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F
SHRUBS														
Amelanchier alnifolia	.	5.7 / 20.	.	.	.	.	1.2 / 10.	5.8 / 34.	.	.	+ / 6.0	+ / 2.0	.	2.5 / 4.0
Abies lasiocarpa	.	.	.	3.7 / 6.0	.	.	.	.	.	.	.	.	.	.
Mahonia repens	.	.	.	.	.	.	.	3.2 / 16.	.	.	.	+ / 2.0	0.5 / 8.0	.
Pachistima myrsinites	.	.	.	.	.	.	2.9 / 8.0	.	.	.	1.1 / 8.0	.	+ / 2.0	.
Populus tremuloides	.	.	.	3.2 / 12.	+ / 2.0	2.1 / 16.	.	.	1.1 / 8.0	0.5 / 8.0	8.3 / 28.	.	.	.

Table B, cont'd.

	Populus - Symphoricarpos h.t.							Populus - Heracleum h.t.				Populus - Carex h.t.		
Stand Number	4	10	49	6	7	37	38	19	35	54	25	26	27	41
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Prunus virginiana	.	+/2.0	.	.	.	.	.	7.5/32.	.	.	.	.	.	7.4/12.
Rosa sp.	.	0.5/8.0	.	.	1.7/8.0	7.1/36.	3.0/22.	5.4/30.	.	.	4.5/36.	8.1/38.	1.7/18.	.
Salix scouleriana	.	.	.	.	.	.	.	.	.	.	.	.	+/2.0	.
Sambucus racemosa	.	.	.	.	.	.	+/2.0	0.6/4.0	.	.	.	.	.	.
Sorbus scopulina	.	.	.	2.2/4.0	+/2.0	.	.	0.6/4.0	8.0/30.	.	.	.	.	.
Symphoricarpos oreophilus	30./82.	35./70.	7.0/32.	34./70.	29./78.	23./52.	22./48.	6.2/12.	2.1/2.0	1.6/2.0	2.1/10.	.	.	0.7/8.0
GRAMINOIDS														
Bromus anomalous	.	.	0.6/6.0	.	.	.	.	1.3/12.	.	.	.	.	.	.
Bromus ciliatus	2.3/16.	1.7/18.	18./76.	.	.	+/6.0	2.3/18.	8.4/54.	20./80.	8.0/32.	4.6/40.	1.1/8.0	0.8/6.0	2.6/24.

Table B, cont'd.

	Populus - Symphoricarpos h.t.							Populus - Heracleum h.t.				Populus - Carex h.t.		
Stand Number	4	10	49	6	7	37	38	19	35	54	25	26	27	41
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Calamagrostis rubescens	3.5/8.0	.	.	.	.	.	.	.	.	.	.	.	.	3.0/8.0
Carex geyeri	27./62.	30./92.	25./68.	46./86.	36./100	49./100	39./100	43./96.	.	32./80.	39./98.	40./100	29./96.	42./92.
Elymus glaucus	3.3/20.	9.6/40.	1.9/16.	5.1/42.	9.6/62.	1.4/18.	6.6/26.	21./78.	6.7/40.	3.6/12.	11./68.	6.8/30.	2.3/20.	14./60.
Festuca thurberi	.	.	.	.	.	.	.	.	.	.	.	.	.	2.3/6.0
Melica spectabilis	+/2.0	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa interior	4.2/26.	.	+/4.0	.	.	.	.	.	3.1/18.	.	+/2.0	12./38.	4.8/20.	.
Poa nevadensis	.	.	.	.	.	.	.	.	.	.	.	.	2.3/12.	.
Poa pratensis	4.6/22.	.	.	.	.	.	.	.	.	.	.	10./24.	.	+/2.0
FORBS														
Achillea millefolium	9.4/60.	4.8/36.	1.9/16.	.	.	3.6/26.	.	1.2/26.	1.4/10.	+/6.0	4.3/50.	5.4/42.	4.8/36.	1.0/20.

Table B, cont'd.

Stand Number	4	10	49	6	7	37	38	19	35	54	25	26	27	41
	Populus - Symphoricarpos h.t.							Populus - Heracleum h.t.			Populus - Carex h.t.			
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Agastache urticifolia	4.8/16.	.	0.7/8.0	.	.	.	.	.	.	.	.	.	.	.
Aquilegia coerulea	.	1.1/8.0	.	4.9/20.	1.4/8.0	+/4.0	.	.	2.5/16.	0.6/10.	.	.	.	.
Arnica cordifolia	.	.	.	.	.	.	.	+/8.0	.	.	6.6/64.	2.9/28.	6.9/58.	.
Arnica parryi	.	.	12./44.	.	.	.	.	.	.	.	.	.	.	.
Aster engelmannii	.	1.1/20.	.	2.7/36.	2.9/18.	8.0/52.	6.4/20.	1.5/4.0	0.2/8.0	+/4.0	.	.	2.8/28.	.
Castilleja sulphurea	.	.	.	.	.	3.1/18.	0.8/8.0	.	.	.	.	.	1.6/14.	0.7/8.0
Chenopodium atrovirens	0.5/10.	.	.	.	.	.	.	.	+/2.0	+/2.0	.	.	.	.
Cirsium sp.	0.9/4.0	.	3.4/20.	+/4.0	.	.	1.2/10.	2.3/32.	1.7/8.0	.	.	.	.	10./40.
Clematis pseudoalpina	.	.	.	.	.	.	.	0.6/4.0	.	.	.	.	.	.
Collomia linearis	.	.	.	.	.	.	.	0.7/8.0	.	.	+/2.0	.	.	.

Table B, cont'd.

	Populus - Symphoricarpos h.t.							Populus - Heracleum h.t.			Populus - Carex h.t.			
Stand Number	4	10	49	6	7	37	38	19	35	54	25	26	27	41
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Delphinium barbeyi	.	+/2.0	.	+/6.0	.	5.8/20.	+/2.0	.	.	+/2.0	.	.	.	.
Descurainia californica	0.8/6.0	.	.	.	.	.	.	.	+/2.0	+/2.0	.	.	.	.
Dugaldia hoopesii	7.8/36.	+/2.0	.	.	.	3.6/12.	21./58.	.	.	.	2.1/22.	+/2.0	.	+/4.0
Epilobium angustifolium	.	.	.	.	.	+/2.0	2.4/22.	1.9/16.	.	3.6/32.	+/4.0	0.5/8.0	+/2.0	0.7/8.0
Erigeron elatior	0.8/6.0	.	.	+/4.0	1.1/8.0	.	2.3/18.	.	.	+/2.0	.	0.8/6.0	.	.
Erigeron speciosus	.	.	.	.	.	+/2.0	.	.	.	.	.	.	+/2.0	.
Fragaria sp.	2.0/18.	.	5.5/28.	4.8/48.	+/6.0	1.4/18.	1.4/18.	2.1/46.	.	.	3.9/42.	+/18.	16./72.	36./88.
Galium aparine	.	.	.	.	.	.	.	7.5/24.	.	.	.	.	.	.
Galium boreale	2.9/28.	2.1/26.	0.8/12.	1.5/22.	2.5/38.	+/12.	+/10.	+/4.0	.	.	.	.	.	.
Geranium cespitosum	0.5/8.0	.	.	.	.	.	.	.	.	.	.	.	.	.

Table B, cont'd.

	Populus - *Symphoricarpos* h.t.							*Populus* - *Heracleum* h.t.			*Populus* - *Carex* h.t.			
Stand Number	4	10	49	6	7	37	38	19	35	54	25	26	27	41
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Geranium richardsonii	2.7/12.	0.9/10.	32./96.	0.9/26.	+/2.0	2.8/28.	2.8/40.	1.3/12.	4.5/32.	23./70.	.	.	.	+/8.0
Heracleum sphondyllium	.	.	.	.	.	+/2.0	.	.	67./92.	48./90.	.	.	.	.
Hydrophyllum capitatum	+/2.0	.	0.9/20.	.	.	.	.	.	.	.	.	.	.	.
Lathyrus leucanthus	14./58.	13./66.	2.5/20.	25./78.	23./88.	12./50.	15./68.	4.8/24.	.	.	13./56.	18./86.	24./82.	15./52.
Ligusticum porteri	0.8/6.0	2.0/8.0	.	5.0/10.	5.0/12.	8.2/28.	8.8/30.	.	.	.	.	.	.	.
Lupinus argenteus	.	16./60.	.	+/2.0	.	6.7/30.	+/2.0	+/8.0	.	.	+/6.0	.	7.0/60.	.
Mertensia ciliata	.	.	.	0.6/12.	+/2.0	.	.	.	.	.	.	.	.	.
Nemophila brevifolia	5.0/30.	.	.	.	.	.	.	.	.	.	.	.	.	.
Osmorhiza occidentalis	.	.	0.6/6.0	.	.	1.2/8.0	.	+/2.0	.	2.3/12.	.	.	.	.
Osmorhiza sp.	0.8/6.0	8.2/66.	9.3/44.	12./62.	3.3/32.	.	.	3.4/58.	35./62.	+/2.0	.	.	.	.

Table B, cont'd.

	Populus - Symphoricarpos h.t.							Populus - Heracleum h.t.			Populus - Carex h.t.			
Stand Number	4	10	49	6	7	37	38	19	35	54	25	26	27	41
Coverage, % / Frequency, %	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F
Pedicularis procera	.	+ / 2.0	.	.	.	.	.	.	.	.	.	.	.	.
Penstemon strictus	.	.	.	1.6 / 12.	.	.	.	.	.	.	.	.	.	.
Potentilla gracilis	+ / 2.0	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudocymopteris montanus	.	.	.	.	.	.	.	.	.	.	+ / 2.0	+ / 2.0	.	.
Polemonium caeruleum	.	.	.	0.8 / 4.0	.	.	.	.	0.8 / 4.0	.	.	.	.	.
Rudbeckia laciniata	.	.	6.7 / 20.	.	.	.	.	.	.	.	.	.	.	.
Senecio serra	.	.	13. / 40.	1.4 / 18.	.	+ / 2.0	.	.	3.3 / 12.	8.2 / 30.	.	.	.	+ / 8.0
Smilacina racemosa	4.0 / 18.	.	.	.	1.1 / 8.0	.	.	.	.	.	2.3 / 30.	2.0 / 18.	+ / 2.0	.
Stellaria jamesiana	12. / 68.	0.8 / 8.0	2.7 / 28.	.	.	+ / 2.0	+ / 2.0	.	10. / 58.	.	.	.	.	.
Streptopus amplexifolius	.	+ / 2.0	.	.	.	.	.	.	.	.	.	.	.	.

Table B, cont'd.

	Populus - Symphoricarpos h.t.								Populus - Heracleum h.t.			Populus - Carex h.t.		
Stand Number	4	10	49	6	7	37	38	19	35	54	25	26	27	41
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Taraxacum sp.	1.9/16.	+/2.0	0.7/8.0	3.6/42.	0.8/8.0	+/6.0	+/6.0	0.7/8.0	.	.	.	+/2.0	.	5.4/40.
Thalictrum fendleri	11./42.	23./66.	25./80.	12./40.	31./80.	37./88.	27./92.	4.4/12.	14./42.	43./96.	20./58.	13./52.	1.1/8.0	11./24.
Thlaspi montanum	.	.	1.2/12.	.	.	.	.	.	.	.	.	.	.	.
Valeriana occidentalis	.	+/2.0	.	+/8.0	1.4/18.	1.2/10.	.	+/4.0	.	.	.	.	.	.
Vicia americana	4.8/32.	5.3/30.	0.7/8.0	13./68.	22./86.	15./58.	27./80.	2.9/24.	.	29./78.	30./88.	18./76.	6.8/32.	31./92.
Viola canadensis	4.9/48.	+/10.	.	1.2/22.	+/6.0	.	+/2.0	.	.	2.5/26.	.	.	.	.
Viola nuttallii	.	.	.	.	.	.	.	+/4.0	.	1.2/10.	.	.	.	.

Table C. Coverage (C) and frequency (F) of undergrowth species in stands of *Populus tremuloides* - *Thalictrum fendleri* and *Populus tremuloides* - *Pteridium aquilinum* habitat types. Coverage of less than 0.5% is indicated by +. Stand numbers, locations, and topographic positions are also given.

	Populus - *Thalictrum* h.t.												*Populus* - *Pteridium* h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Location:													
Section	33	24	20	30	32	23	2	21	17	30	25	25	1
Township	3S	3S	3S	3S	3S	8S	11S	7S	7S	4S	4S	5S	11S
Range	92W	93W	92W	92W	90W	90W	89W	83W	83W	87W	88W	82W	89W
Topo. Position													
Slope, %	15	--	20	8	17	30	10	40	40	--	10	15	--
Aspect, °	56	--	50	120	106	114	166	186	166	--	150	346	--
Elevation, m	2736	2858	2781	2682	2957	2877	2560	2865	3002	3033	3048	2819	2682
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
SHRUBS													
Abies lasiocarpa	.	.	.	.	.	.	.	.	4.8/6.0	.	.	.	.
Amelanchier alnifolia	.	.	.	.	.	.	3.6/12.	.	.	.	.	.	.
Pachistima myrsinites	.	.	+/4.0	.	.	.	.	+/2.0	.	.	.	.	.
Populus tremuloides	3.9/35.	.	+/2.0	1.3/16.	+/2.0	.	.	.	+/6.0	4.8/24.	.	+/4.0	5.8/28.
Rosa sp.	.	.	+/6.0	0.7/8.0	.	.	1.3/12.	.	.	.	.	.	.
Rubus parviflorus	.	.	.	.	.	.	.	.	.	.	.	2.0/8.0	.

Table C, cont'd.

	Populus - *Thalictrum* h.t.												*Populus* - *Pteridium* h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Sambucus racemosa	.	.	.	.	.	+/2.0	.	.	.	.	.	2.0/8.0	.
Symphoricarpos oreophilus	7.3/22.	3.7/12.	6.1/20.	9.3/23.	.	.	14./40.	.	.	.	.	.	5.3/18.
GRAMINOIDS													
Bromus anomalous	.	.	.	2.3/10.	.	1.8/8.0	3.7/10.	.	.	.	2.9/12.	3.0/22.	.
Bromus ciliatus	7.8/72.	5.6/62.	4.3/22.	16./74.	1.8/12.	11./70.	.	+/2.0	9.1/36.	0.8/12.	1.2/8.0	5.1/50.	1.5/10.
Calamagrostis rubescens	.	+/2.0	.	.	.	.	.	.	.	.	.	.	1.0/6.0
Carex geyeri	4.7/20.	6.5/22.	20./72.	19./80.	.	0.7/4.0	59./92.	30./80.	41./92.	25./60.	2.7/12.	24./74.	4.9/28.
Carex sp.	.	.	.	.	.	.	.	.	.	.	.	.	+/2.0
Elymus glaucus	8.0/52.	5.2/40.	27./88.	7.8/50.	7.2/60.	+/4.0	16./70.	1.9/6.0	+/2.0	9.9/32.	0.7/8.0	11./62.	7.9/40.
Melica spectabilis	.	1.1/24.	.	.	5.2/42.	2.4/10.	.	.	.	.	.	.	.

Table C, cont'd.

	Populus - *Thalictrum* h.t.												*Populus* - *Pteridium* h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Poa agassizensis	.	.	.	+/4.0	.	.	+/8.0	.	.	.	.	+/6.0	.
Poa leptocoma	.	+/2.0	.	.	.	.	+/4.0	.	.	.	.	.	.
Poa pratensis	.	.	.	.	.	+/4.0	.	.	0.9/6.0	.	.	+/2.0	.
Poa trivialis	.	.	.	.	.	.	.	.	.	.	.	+/2.0	.
FORBS													
Achillea millefolium	.	+/2.0	.	7.5/42.	.	.	+/8.0	.	.	.	.	3.2/50.	2.9/28.
Actaea rubra	.	.	.	.	.	.	.	.	.	.	.	.	0.9/4.0
Agastache urticifolia	+/2.0	.	.	.	3.2/12.	.	.	.	.	.	.	.	.
Androsace septentrionalis	.	.	.	.	+/2.0	.	.	.	.	.	.	.	.

Table C, cont'd.

	Populus - Thalictrum h.t.												Populus - Pteridium h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Aquilegia caerulea	0.8/8.0	+/4.0	0.7/6.0	.	2.2/26.	+/4.0	.	1.7/10.	.	+/12.	+/10.	.	.
Arnica cordifolia	.	.	.	.	.	.	.	.	.	.	.	+/16.	.
Arnica parryi	.	.	.	.	.	+/4.0	.	.	+/2.0	.	.	.	.
Aster engelmannii	4.0/18.	3.6/26.	6.3/50.	.	5.3/10.	2.5/16.	3.1/46.	+/2.0	0.9/12.	2.3/16.	.	+/4.0	3.8/20.
Castilleja sulphurea	.	.	.	.	.	.	.	.	.	.	.	0.9/16.	.
Cerastium arvense	.	+/2.0	.	.	.	.	.	.	.	.	.	.	.
Chenopodium atrovirens	.	+/2.0	.	.	.	.	+/4.0	.	.	.	.	.	.
Cirsium sp.	+/6.0	+/4.0	+/2.0	0.7/8.0	3.4/38.	+/6.0	.	.	.	.	+/4.0	2.5/24.	+/2.0
Collomia linearis	.	.	+/2.0	.	.	.	.	.	.	.	.	.	.

Table C, cont'd.

	Populus - Thalictrum h.t.												Populus - Pteridium h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Delphinium barbeyi	0.7/6.0	.	0.6/14.	.	.	0.8/6.0	.	.	1.1/8.0	.	18./36.	.	1.4/10.
Descurainia californica	.	.	.	0.7/8.0	.	.	.	.	.	.	.	.	.
Draba sp.	.	1.1/14.	.	.	.	.	.	.	.	.	.	.	.
Dugaldia hoopesii	.	3.7/14.	.	.	4.8/28.	.	.	0.6/4.0	.	0.6/4.0	.	.	.
Epilobium angustifolium	+/2.0	0.9/6.0	+/2.0	3.3/20.	.	.	.	12./52.	20./86.	.	1.4/16.	0.6/4.0	0.4/6.0
Erigeron elatior	.	0.7/6.0	.	.	.	.	.	0.9/8.0	.	+/4.0	0.6/4.0	3.4/24.	+/4.0
Erigeron speciosus	.	.	+/4.0	.	.	0.5/6.0	.	.	.	.	.	+/4.0	.
Fragaria sp.	+/6.0	3.3/32.	1.3/14.	.	.	+/2.0	+/8.0	+/6.0	.	+/8.0	.	6.7/80.	4.8/42.
Galium aparine	.	.	.	.	+/4.0	.	.	.	.	.	.	.	.
Galium boreale	0.9/10.	0.9/6.0	0.8/20.	4.4/62.	.	2.9/30.	0.6/24.	.	.	.	.	4.6/70.	5.1/68.

Table C, cont'd.

	Populus - *Thalictrum* h.t.												*Populus* - *Pteridium* h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Geranium richardsonii	4.8/32.	3.2/24.	11./62.	4.4/46.	.	0.6/10.	.	34./90.	25./75.	8.8/64.	0.9/16.	11./58.	3.9/38.
Heracleum sphondyllium	7.7/45.	+/2.0	+/2.0	0.6/4.0	.	10./50.	.	8.2/28.	11./28.	.	.	.	8.2/20.
Hydrophyllum capitatum	2.9/20.	5.6/30.	2.1/12.	.	+/2.0	15./60.	.	.	.	.	.	.	.
Hydrophyllum fendleri	3.6/24.	.	.	.	.	.	+/2.0	.	.	.	+/4.0	.	.
Lathyrus leucanthus	15./48.	2.5/14.	10./42.	9.0/46.	6.6/36.	0.8/8.0	3.7/32.	22./70.	2.6/12.	32./80.	0.8/12.	14./70.	9.4/48.
Ligusticum porteri	.	60./90.	12./20.	.	26./60.	27./58.	8.8/28.	.	.	50./72.	52./76.	.	.
Lupinus argenteus	1.9/16.	2.6/18.	7.4/46.	0.6/16.	.	.	10./54.	1.3/22.	.	.	.	5.5/46.	.
Mertensia ciliata	.	.	.	.	.	.	.	.	.	9.0/56.	18./72.	.	+/2.0
Nemophila breviflora	.	.	.	.	+/2.0	9.0/42.	.	.	.	.	.	.	.

Table C, cont'd.

	Populus - Thalictrum h.t.												Populus - Pteridium h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Osmorhiza occidentalis	.	.	5.9/20.	5.1/34.	.	.	5.7/28.	.	.	.	.	2.0/18.	1.3/6.0
Osmorhiza sp.	15./52.	17./44.	4.4/26.	13./70.	36./78.	25./80.	8.8/54.	.	.	0.6/4.0	26./64.	5.0/66.	13./50.
Pedicularis bracteosa	.	+/2.0	0.6/4.0	.	.	.	.	9.0/34.	.	18./32.	.	.	.
Pedicularis procera	+/2.0	.	.	.	.	.	.	1.0/12.	1.3/6.0	.	.	.	.
Penstemon whippleanus	.	.	.	+/2.0	.	.	.	.	.	.	.	.	.
Phacelia heterophylla	.	.	.	+/4.0	.	.	.	.	.	.	.	.	.
Polemonium caeruleum	.	.	.	.	.	5.1/18.	.	.	.	.	.	.	+/2.0
Potentilla gracilis	.	.	.	.	.	.	.	.	.	.	.	.	+/4.0
Pteridium aquilinum	.	.	.	.	.	.	.	.	.	.	.	.	78./96.
Rudbeckia laciniata	.	.	7.1/34.	.	.	.	.	.	.	.	.	.	4.3/22.

Table C, cont'd.

	Populus - *Thalictrum* h.t.												*Populus* - *Pteridium* h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Senecio crassulus	.	.	.	7.0/42.	.	.	.	1.3/10.	.	.	.	.	.
Senecio serra	.	.	+/2.0	1.0/20.	3.6/22.	+/6.0	.	2.1/8.0	3.8/20.	4.1/28.	8.0/38.	2.4/24.	+/2.0
Smilacina racemosa	0.7/6.0	.	.	.	.	.	.	0.9/6.0	5.7/28.	.	.	.	0.9/4.0
Smilacina stellata	.	.	.	+/8.0	.	.	.	.	.	.	.	.	.
Solidago spathulata	.	.	.	.	.	.	.	.	.	.	.	3.6/32.	
Stellaria jamesiana	17./78.	12./70.	5.4/60.	4.3/42.	12./92.	4.3/28.	.	+/2.0	.	1.1/24.	9.0/64.	.	.
Streptopus amplexicaulus	.	.	.	.	.	.	.	.	.	.	.	.	+/4.0
Taraxacum sp.	.	.	+/2.0	+/8.0	.	.	0.7/8.0	+/2.0	+/2.0	.	.	0.9/16.	2.1/22.
Thalictrum fendleri	21./58.	6.6/24.	45./88.	18./54.	19./48.	1.9/8.0	36./92.	24./84.	37./100	21./68.	59./88.	7.1/12.	8.5/18.
Thlaspi montanum	.	.	.	.	0.5/8.0	.	.	.	.	.	+/4.0	.	.

Table C, cont'd.

	Populus - *Thalictrum* h.t.												*Populus* - *Pteridium* h.t.
Stand Number	2	3	11	16	34	24	15	5	53	39	40	18	14
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Trillium ovatum	.	.	.	.	+/8.0	4.0/36.	.	.	.	.	.	.	.
Valeriana occidentalis	0.7/6.0	4.0/16.	3.2/24.	.	6.3/25.	9.2/36.	+/4.0	4.1/24.	+/2.0	1.3/12.	1.2/8.0	.	+/2.0
Veratrum tenuipetalum	.	.	.	.	.	0.5/6.0	.	.	.	.	.	.	.
Vicia americana	3.1/16.	1.0/8.0	4.9/30.	8.8/54.	.	+/2.0	32./70.	14./64.	25./70.	30./64.	.	9.4/58.	8.1/36.
Viola canadensis	.	.	+/2.0	.	.	.	.	1.3/10.	0.9/10.	.	.	.	1.9/28.
Viola nuttallii	.	0.7/8.0	.	0.5/20.	.	+/2.0	0.6/4.0	7.1/60.	4.8/58.	5.5/48.	1.4/36.	.	2.8/24.
Wyethia amplexicaulis	.	.	.	.	.	.	.	.	.	0.6/4.0	.	.	.

Table D. Coverage (C) and frequency (F) of undergrowth species in stands of *Pseudotsuga menziesii* - *Pachistima myrsinites* habitat type. Coverage of less than 0.5% is indicated by +. Stand numbers, locations, and topographic positions are also given.

Stand Number	36	57
Location:		
Section	17	20
Township	8S	8S
Range	83W	83W
Topographic Position:		
Slope, %	56	64
Aspect, °	266	290
Elevation, m	2560	2697
Coverage, % / Frequency, %	C / F	C / F
SHRUBS		
Acer glabrum	1.1 / 8.0	.
Amelanchier alnifolia	.	0.8 / 6.0
Clematis pseudoalpina	.	1.5 / 10.
Juniperus communis	+ / 2.0	3.1 / 16.
Juniperus scopulorum	.	2.1 / 4.0
Mahonia repens	.	3.0 / 28.
Pachistima myrsinites	35. / 88.	21. / 76.
Ramischia secunda	+ / 2.0	.
Rosa sp.	3.2 / 30.	3.8 / 28.
Shepherdia canadensis	+ / 2.0	1.4 / 8.0
Symphoricarpos oreophilus	1.7 / 8.0	4.6 / 20.

Table D, cont'd.

Stand Number	36	57		36	57
Coverage, % / Frequency, %	C/F	C/F		C/F	C/F
GRAMINOIDS			*Lathyrus leucanthus*	+/2.0	.
Calamagrostis rubenscens	0.5/10.	.	Mosses + Lichens	14./56.	27./78.
Carex geyeri	2.1/12.	2.6/20.	*Osmorhiza depauperata*	+/2.0	+/2.0
Poa sp.	+/2.0	.	*Pseudocymopteris montanus*	+/8.0	.
FORBS			*Senecio wootoni*	0.8/8.0	.
Antennaria microphylla	+/6.0	.	*Smilacina racemosa*	.	+/4.0
Aquilegia coerulea	1.1/20.	+	*Solidago multiradiata*	1.6/16.	+/6.0
Arnica cordifolia	1.4/10.	+/4.0	*Solidago spathulata*	.	0.5/6.0
Epilobium angustifolium	+/2.0	0.5/6.0			
Fragaria sp.	+/2.0	+/2.0			
Galium boreale	.	0.9/10.			

Table E. Coverage (C) and frequency (F) of undergrowth species in stands of the *Abies lasiocarpa* - *Carex geyeri* habitat type. Coverage of less than 0.5% is indicated by +. Stand numbers, locations, and topographic positions are also given.

Stand Number	48	17	43	44	8
Location:					
Section	18	12	34	34	12
Township	3S	8S	8S	8S	11S
Range	91W	90W	90W	90W	89W
Topographic Position:					
Slope, %	--	--	45	43	40
Aspect, °	--	--	271	269	296
Elevation, m	2850	2804	2941	2960	2713
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F
SHRUBS					
Abies lasiocarpa	4.4/20.	21./40.	13./34.	12./40.	9.3/18.
Amelanchier alnifolia	.	.	.	.	+/2.0
Lonicera involucrata	6.3/10.	.	.	.	.
Pachistima myrsinites	.	.	4.1/44.	5.0/46.	.
Picea engelmannii	.	.	.	+/4.0	.
Populus tremuloides	.	.	.	.	+/2.0
Ramischia secunda	2.4/16.	.	+/4.0	+/8.0	.
Ribes cereum	+/4.0	.	.	.	.
Ribes montigenum	.	.	+/4.0	+/2.0	.
Rosa sp.	.	.	.	.	+/6.0
Rubus idaeus	2.4/6.0	.	.	.	.

Table E, cont'd.

Stand Number Coverage, % / Frequency, %	48 C/F	17 C/F	43 C/F	44 C/F	8 C/F
Rubus parviflorus	16./48.	.	.	.	4.6/30.
Symphoricarpos oreophilus	.	.	.	.	21./58.
Vaccinium myrtillus	.	.	0.7/8.0	.	.
Vaccinium scoparium	.	.	0.8/16.	.	+/2.0
GRAMINOIDS					
Bromus ciliatus	.	3.1/28.	.	.	9.8/52.
Calamagrostis rubescens	.	.	.	.	0.8/6.0
Carex geyeri	21./33.	29./82.	6.9/42.	5.9/24.	7.9/30.
Elymus glaucus	.	1.7/30.	.	.	.
Melica spectabilis	.	+/4.0	.	.	.
Poa nervosa	+/2.0	.	.	.	+/6.0
FORBS					
Achillea millefolium	.	+/4.0	.	.	+/6.0
Actaea rubra	.	0.6/4.0	.	.	.
Aquilegia caerulea	.	0.5/18.	+/4.0	.	.
Arnica cordifolia	.	.	7.6/52.	0.5/20.	3.4/28.

Table E, cont'd.

Stand Number	48	17	43	44	8
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F
Aster engelmannii	2.8/30.	0.6/4.0	0.7/8.0	5.2/36.	11./58.
Cirsium sp.	.	4.3/26.	.	.	.
Colomia linearis	.	.	.	.	+/4.0
Delphinium barbeyi	.	4.1/20.	.	.	0.8/8.0
Descurainia californica	+/2.0	.	.	.	.
Epilobium angustifolium	.	.	0.7/8.0	.	.
Erigeron elatior	0.5/10.	.	.	.	.
Erigeron speciosus	.	0.9/16.			
Fragaria sp.	.	1.0/20.	.	.	2.3/30.
Galium aparine	1.3/8.0	.	.	.	.
Galium boreale	.	1.3/32.	+/4.0	+/8.0	3.3/56.
Geranium richardsonii	+/4.0	3.3/54.	+/4.0	.	1.2/22.
Heracleum sphondyllium	.	1.2/12.	.	.	.
Hydrophyllum fendleri	.	3.0/24.	.	.	.
Lathyrus leucanthus	.	0.7/8.0	4.2/32.	0.9/16.	17./70.

Table E, cont'd.

Stand Number Coverage, % Frequency, %	48 C/F	17 C/F	43 C/F	44 C/F	8 C/F
Ligusticum porteri	2.2/8.0	3.6/16.	4.1/20.	+/4.0	0.8/8.0
Lupinus argenteus	.	.	.	.	2.2/6.0
Mosses + Lichens	.	.	2.4/28.	5.0/28.	.
Osmorhiza depauperata	5.2/44.	2.0/18.	0.4/16.	0.3/18.	.
Osmorhiza sp.	0.6/10.	.	+/8.0	.	+/6.0
Pedicularis racemosa	1.3/6.0	.	0.5/4.0	2.2/12.	.
Polemonium caeruleum	+/2.0	.	.	.	.
Potentilla gracilis	.	+/4.0	.	.	.
Pseudocymopteris montanus	.	.	.	+/8.0	+/8.0
Ranunculus uncinatus	.	.	.	.	+/2.0
Senecio serra	0.5/4.0	+/4.0	.	.	.
Senecio wootonii	.	5.1/24.	.	.	.
Smilacina racemosa	+/4.0	.	.	.	.
Smilacina stellata	.	4.0/20.	.	.	.
Solidago multiradiata	.	.	0.8/12.	+/6.0	.

Table E, cont'd.

Stand Number	48	17	43	44	8
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F
Solidago spathulata	.	+/4.0	+/2.0	.	.
Stellaria jamesiana	.	0.6/24.	.	.	.
Taraxacum sp.	.	1.7/32.	.	.	+/4.0
Thalictrum fendleri	1.3/8.0	12./50.	.	.	.
Thlaspi montanum	.	+/8.0	.	.	.
Trillium ovatum	.	.	.	.	+/2.0
Valeriana occidentalis	.	11./62.	.	.	.
Vicia americana	.	+/6.0	.	.	2.0/18.
Viola canadensis	+/8.0	4.5/50.	.	.	0.9/10.
Viola nuttallii	.	+/4.0	.	.	.

Table F. Coverage (C) and frequency (F) of undergrowth species in stands of the Abies lasiocarpa - Vaccinium scoparium habitat type. Coverage of less than 0.5% is indicated by +. Stand numbers, locations, and topographic positions are also given.

Stand Number	9	50	51	1	55	12	28	13	42	22	23	47	46	52	21	20	45
Location:																	
Section	12	21	5	6	21	25	15	31	23	3	1	14	20	30	17	17	2
Township	11S	9S	9S	9S	8S	8S	8S	8S	6S	6S	6S	4S	4S	4S	4S	4S	6S
Range	89W	84W	84W	84W	82W	82W	83W	82W	83W	80W	80W	81W	81W	80W	81W	81W	80W
Topo. Position:																	
Slope, %	25	40	---	12	33	27	38	30	12	27	19	20	20	25	35	12	15
Aspect, °	320°	286	---	292	176	196	326	190	273	286	86	286	4	292	326	26	181
Elevation, m	2743	2972	3048	3231	2896	2972	3050	3078	2941	3261	3414	2896	2957	3048	3063	3078	3353
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
SHRUBS																	
Abies lasiocarpa	8.4/28.	0.8/12.	5.5/12.	3.6/20.	.	.	.	.	1.6/6.0	.	6.2/16.	4.4/24.	.	.	.	+/2.0	+/2.0
Juniperus communis	.	2.4/4.0	.	.	.	.	.	0.7/2.0	2.0/8.0	.	.	.	.	.	.	.	.
Mahonia repens	.	.	.	.	+/2.0	0.8/4.0	.	+/4.0	.	.	.	.	.	.	.	.	.
Pachistima myrsinites	+/6.0	12./56.	.	.	+/8.0	0.8/14.	+/2.0	0.5/10.	3.1/28.	.	.	+/6.0	+/4.0	1.0/20.	0.8/10.	+/6.0	.
Picea engelmannii	.	2.1/8.0	.	1.8/6.0	.	.	+/2.0	.	.	.	.	+/4.0	.	.	.	.	.
Ramischia secunda	.	0.6/4.0	.	.	.	.	0.9/10.	.	0.9/10.	2.4/20.	+/2.0	.	+/12.	.	1.6/14.	+/2.0	.
Rosa sp.	.	.	.	.	1.7/28.	1.8/34.	0.5/8.0	4.6/42.	+/2.0	.	.	.	.	.	.	.	.

Table F, cont'd.

Stand Number	9	50	51	1	55	12	28	13	42	22	23	47	46	52	21	20	45
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Rubus parviflorus	+/2.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Shepherdia canadensis	.	.	.	.	.	4.9/10.	.	14./26.	.	.	.	+/4.0	.	4.0/8.0	.	.	.
Sorbus scopulina	.	.	.	+/2.0	.	.	.	.	.	.	.	.	.	.	.	.	.
Symphoricarpos oreophilus	0.9/4.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium cespitosum	.	.	.	.	.	.	+/2.0	.	.	.	1.7/12.	.	.	.	.	.	.
Vaccinium myrtillus	2.1/12.	.	0.7/6.0	16./50.	.	0.6/4.0	7.4/52.	+/2.0	11./72.	1.7/12.	19./76.	6.8/56.	1.3/12.	1.5/20.	11./72.	7.5/42.	11./68.
Vaccinium scoparium	15./58.	49./92.	77./100	30./72.	30./76.	21./88.	42./98.	28./80.	12./78.	5.2/32.	25./82.	70./100	34./88.	43./100	37./98.	35./96.	60./100
GRAMINOIDS																	
Bromus ciliatus	+/4.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calamagrostis inexpansa	.	+/4.0	.	.	.	.	.	.	+/2.0	0.7/8.0	.	.	.	.	.	.	.
Carex geyeri	+/2.0	.	6.4/40.	1.4/8.0	9.8/44.	0.7/2.0	.	+/8.0	.	0.6/6.0	13./46.	.	.	.	+/2.0	5.4/32.	23./64.
Elymus glaucus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+/4.0	.

Table F, cont'd.

Stand Number	9	50	51	1	55	12	28	13	42	22	23	47	46	52	21	20	45
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Poa nemoralis	.	.	.	.	+/2.0	.	.	.	.	+/4.0	.	.	0.5/14.	.	.	.	.
Poa nervosa	+/2.0	.	.	.	.	.	+/6.0	.	.	.	.	.	2.7/28.	.	.	.	+/4.0
Poa pratensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+/4.0	.
FORBS																	
Achillea millefolium	.	.	.	+/2.0	.	.	.	+/2.0	.	.	.	.	.	.	.	.	.
Antennaria microphylla	.	.	.	.	.	+/2.0	.	.	.	.	.	.	.	.	.	.	.
Arnica cordifolia	5.5/50.	9.0/56.	0.6/8.0	0.7/18.	0.6/6.0	3.6/32.	1.0/18.	1.0/22.	12./66.	14./88.	3.0/36.	.	5.7/36.	1.1/24.	10./58.	21./64.	4.4/24.
Arnica latifolia	.	.	.	.	.	.	.	.	.	+/2.0	.	.	.	.	.	.	.
Aster engelmannii	0.9/10.	.	.	.	.	.	.	.	.	.	.	.	2.9/36.	.	.	+/2.0	.
Campanula rotundifolia	.	.	.	.	.	+/6.0	.	.	.	.	.	.	.	.	.	+/2.0	.
Castilleja sulphurea	.	.	.	.	.	.	.	.	+/2.0	.	.	.	.	.	.	.	.
Epilobium angustifolium	.	0.9/16.	.	+/4.0	.	+/2.0	+/6.0	+/2.0	+/2.0	.	.	.	+/4.0	.	.	0.9/6.0	.

Table F, cont'd.

Stand Number	9	50	51	1	55	12	28	13	42	22	23	47	46	52	21	20	45
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
Erigeron peregrinus	.	0.6/4.0	.	.	.	.	.	+/4.0	.	.	+/2.0	.	.	.	.	+/2.0	.
Fragaria sp.	.	.	.	+/4.0	.	.	+/2.0	1.9/28.	.	0.7/8.0	.	.	.	.	.	.	.
Galium boreale	1.1/18.	.	.	.	.	+/2.0	.	.	.	+/2.0	.	.	.	+/2.0	.	.	.
Hieracium albiflorum	.	.	.	+/2.0	0.8/12.	+/6.0	.	.	.	.	.	.	.	.	.	+/2.0	.
Lathyrus leucanthus	.	5.3/40.	.	.	.	.	.	.	11./30.	.	.	0.8/12.	8.7/44.	6.0/48.	3.2/28.	8.0/40.	.
Ligusticum porteri	.	.	.	.	.	.	.	.	.	2.1/14.	.	.	.	.	.	.	.
Lupinus argenteus	.	0.8/12.	.	4.5/32.	.	.	+/2.0	.	.	.	4.9/32.	.	5.1/68.	.	.	.	1.2/8.0
Mertensia ciliata	.	.	.	.	.	.	.	.	.	5.6/28.	.	.	.	.	.	.	.
Mosses + Lichens	1.0/16.	.	1.9/16.	10./36.	1.1/24.	+/4.0	7.4/40.	.	+/10.	5.8/20.	1.5/10.	20./64.	5.6/32.	5.0/48.	16./52.	+/2.0	0.8/12.
Osmorhiza depauperata	+/6.0	.	.	+/2.0	.	.	.	+/2.0	.	4.6/28.	.	.	.	.	.	.	.
Pedicularis racemosa	.	+/12.	11./44.	.	.	.	.	.	.	+/2.0	11./38.	+/2.0	+/12.	.	0.7/6.0	+/2.0	8.2/24.

Table F, cont'd.

Stand Number	9	50	51	1	55	12	28	13	42	22	23	47	46	52	21	20	45
Coverage, % / Frequency, %	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F
Polemonium caeruleum	.	.	.	+ / 2.0	.	.	.	.	.	1.3 / 12.	.	.	.	.	.	+ / 2.0	.
Potentilla gracilis	.	+ / 2.0	.	.	.	.	+ / 4.0	.	.	+ / 4.0	.	.	.	.	+ / 4.0	.	.
Pseudocymopteris montanus	+ / 2.0	.	.	.	+ / 2.0	.	.	+ / 4.0	.	.	.	+ / 2.0	.	.	.	+ / 2.0	.
Senecio serra	.	.	.	.	.	+ / 12.	.	.	2.4 / 18.	.	.	.	.	.	.	+ / 2.0	.
Senecio wootonii	.	.	.	.	.	.	+ / 6.0	.	.	.	.	.	+ / 4.0	.	.	.	.
Smilacina racemosa	+ / 2.0	0.6 / 8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Solidago multiradiata	.	0.9 / 16.	.	0.5 / 8.0	+ / 4.0	2.8 / 34.	.	2.1 / 26.	3.4 / 30.	.	.	.	+ / 4.0	.	.	+ / 8.0	.
Solidago spathulata	.	.	.	+ / 4.0	.	.	.	+ / 6.0	.	.	0.5 / 12.	.	.	.	.	.	+ / 6.0
Vicia americana	.	.	.	.	.	.	.	.	0.8 / 20.	.	.	.	0.4 / 16.	1.2 / 24.	.	2.2 / 30.	.
Viola nuttallii	0.6 / 10.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+ / 4.0	.

Table G. Edaphic characteristics of the upper dm of mineral soil within each stand. Data are listed by habitat type.

Stand	Total N, %	O.M. %	P lbs/A	K lbs/A	pH	Salts mmho/cm	Ca ppm	Mg ppm	% Sand	% Silt (textural name)	% Clay
				Populus tremuloides - *Symphoricarpos oreophilus* h.t.							
4	.39	5.9	65	580	6.6	0.5	2879	131	32.4	44.7 (loam)	22.9
10	.47	7.2	54	540	6.3	0.5	3384	126	22.4	46.7 (clay loam)	30.9
6	.33	4.1	67	920	6.0	0.5	2626	182	27.1	42.7 (clay loam)	30.2
7	.34	4.7	98	820	6.2	0.5	2525	147	28.4	44.7 (loam)	26.9
37	.32	4.3	62	560	6.6	0.4	2929	192	30.6	36.9 (clay loam)	32.5
38	.27	3.4	83	490	5.8	0.3	2626	187	22.8	41.6 (clay loam)	35.5
19	.27	5.0	173	670	6.0	0.5	1970	157	45.1	34.7 (loam)	20.2
				Populus tremuloides - *Heracleum sphondyllium* h.t.							
35	.37	5.2	70	890	7.4	0.5	4798	101	20.6	42.3 (clay loam)	37.2
54	.26	3.8	12	360	6.3	0.3	1919	172	22.0	46.1 (clay loam)	31.9

Table G, cont'd.

Stand	Total N, %	O.M. %	P lbs/A	K lbs/A	pH	Salts mmho/cm	Ca ppm	Mg ppm	% Sand	% Silt (textural name)	% Clay
					Populus tremuloides - *Carex geyeri* h.t.						
25	.13	2.2	34	460	6.2	0.3	1263	81	58.4	24.4	17.2
										(sandy loam)	
26	.13	2.0	13	350	6.1	0.3	1212	126	52.8	29.4	17.8
										(loam)	
27	.15	2.5	42	360	6.0	0.3	1111	86	53.1	30.1	16.8
										(sandy loam)	
41	.20	3.1	16	490	6.2	0.3	2323	177	25.5	49.6	24.9
										(loam)	
					Populus tremuloides - *Thalictrum fendleri* h.t.						
2	.42	6.6	76	580	6.2	0.5	3737	197	18.4	48.7	32.9
										(silty clay loam)	
3	.38	6.2	47	520	6.0	0.5	2273	111	36.4	42.7	20.9
										(loam)	
11	.45	6.6	56	420	6.3	0.5	3889	207	24.4	48.7	26.9
										(loam)	
16	.32	5.0	86	380	6.2	0.5	2323	126	60.9	22.0	17.2
										(sandy loam)	
34	.31	4.6	21	500	6.7	0.4	2576	162	29.6	40.3	30.2
										(clay loam)	

Table G, cont'd.

Stand	Total N, %	O.M. %	P lbs/A	K lbs/A	pH	Salts mmho/cm	Ca ppm	Mg ppm	% Sand	% Silt (textural name)	% Clay
24	.32	5.0	51	890	6.1	0.4	3182	237	26.1	37.7	36.2
										(clay loam)	
15	.39	5.2	102	1500	6.2	0.5	4141	338	37.4	32.1	30.5
										(clay loam)	
5	.27	3.2	32	520	6.1	0.4	1364	111	22.4	50.7	26.9
										(silt loam)	
53	.36	4.3	22	470	6.0	0.3	1818	111	30.0	44.1	25.9
										(loam)	
39	.30	3.3	75	670	5.8	0.3	1869	232	37.5	29.6	32.9
										(clay loam)	
40	.32	4.2	113	570	6.1	0.3	2828	288	33.5	30.0	36.5
										(clay loam)	
18	.24	3.8	127	1070	6.3	0.5	2020	136	45.1	31.7	23.2
										(loam)	
Populus tremuloides - *Pteridium aquilinum* h.t.											
14	.30	5.2	65	830	6.0	0.4	3737	253	30.4	39.4	30.2
										(clay loam)	
Pseudotsuga menziesii - *Pachistima myrsinites* h.t.											
57	.10	2.4	52	480	6.5	0.4	2020	128	55.6	26.2	18.2
										(sandy loam)	

Table G. cont'd.

Stand	Total N, %	O.M. %	P lbs/A	K lbs/A	pH	Salts mmho/cm	Ca ppm	Mg ppm	% Sand	% Silt (textural name)	% Clay
					Abies lasiocarpa - *Carex geyeri* h.t.						
48	.13	2.8	75	170	6.0	0.3	1470	76	28.8	49.7 (loam)	21.5
17	.30	4.6	106	590	6.1	0.5	2172	101	27.1	46.7 (loam)	26.2
43	.08	2.8	69	250	5.6	0.3	1919	141	40.1	34.0 (loam)	25.9
44	.12	2.9	65	320	5.4	0.3	1869	157	44.7	28.8 (loam)	26.5
8	.35	5.7	21	310	5.9	0.5	2374	197	28.4	42.7 (clay loam)	28.9
					Abies lasiocarpa - *Vaccinium scoparium* h.t.						
9	.30	5.9	153	490	5.5	0.5	2020	136	26.4	46.7 (loam)	26.9
50	.74	2.1	58	210	5.2	0.3	860	126	30.0	50.8 (silt loam)	19.2
51	.83	1.9	34	190	4.8	0.3	657	66	33.4	42.7 (loam)	23.9
1	.11	2.8	38	180	4.9	0.4	1010	106	32.4	44.7 (loam)	22.9
55	.07	2.2	35	130	5.2	0.2	455	51	58.0	26.1 (sandy loam)	15.9

Table G, cont'd.

Stand	Total N, %	O.M. %	P lbs/A	K lbs/A	pH	Salts mmho/cm	Ca ppm	Mg ppm	% Sand	% Silt (textural name)	% Clay
12	.12	4.2	72	210	5.5	0.3	859	76	53.1	28.7 (sandy loam)	18.2
28	.07	2.4	49	240	5.1	0.3	606	81	48.1	35.1 (loam)	16.8
13	.18	3.9	88	220	5.4	0.4	657	56	52.4	33.4 (loam)	14.2
42	.07	1.6	240	360	5.7	0.3	707	81	24.8	53.3 (silt loam)	21.9
22	.22	3.4	90	180	5.2	0.4	2172	384	32.8	39.4 (loam)	27.8
23	.18	3.8	65	190	5.0	0.4	758	76	44.8	29.1 (loam)	26.2
47	.06	2.2	173	200	5.2	0.2	505	76	36.1	44.7 (loam)	19.2
46	.07	2.0	144	280	5.4	0.3	909	111	33.8	44.1 (loam)	22.2
52	.10	2.7	232	260	5.5	0.2	455	40	39.0	42.1 (loam)	18.9
21	.11	3.3	170	280	5.3	0.4	960	91	25.0	50.9 (silt loam)	24.2
20	.13	4.6	60	220	5.1	0.4	758	66	33.1	42.7 (loam)	24.2
45	.24	3.5	63	360	5.2	0.3	1566	136	34.0	38.4 (loam)	27.5